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6. AUTHOR(S)
Maria T. Bulzacchelli, PhD, Sandra I. Sulsky, MPH, PhD, Lei Zhu, MS, Sylvia Brandt, PhD, Andrew Barenberg, PhD

Department of Health Promotion and Policy, University of Massachusetts-Amherst
Ramboll-Environ, Amherst, Massachusetts
Center for Public Policy and Administration, University of Massachusetts-Amherst

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Office of Grants and Contracts
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14. ABSTRACT

The purpose of this project was to use data from the US Army Research Institute of Environmental Medicine, Total Army Injury and Health Outcomes Database (TAIHOD) to analyze the direct medical costs to the Army of injuries occurring during Basic Combat Training (BCT) and to identify factors associated with injuries having the greatest impact on the Army. The specific project objectives were as follows: 1) Identify injuries and associated medical care and costs, 2) identify BCT injuries with substantial impact on the Army, and 3) identify risk factors for BCT injuries with substantial impact on the Army. Approximately 40% of men and 61% of women sustained BCT-related injuries from 2002 to 2007. The most common types of injuries were sprains, strains, joint pain, and back pain. For each injured trainee, the Army incurs an estimated $872 in additional direct medical costs, which amounts to approximately $22 million annually.

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The Cost of Basic Combat Training Injuries in the U.S. Army: Injury-Related Medical Care and Risk Factors

Final Technical Report

Prepared for

Military Performance Division
U.S. Army Research Institute of Environmental Medicine
Natick, Massachusetts

Prepared by

Maria T. Bulzacchelli, PhD[1]
Sandra I. Sulsky, MPH, PhD[2]
Lei Zhu, MS[2]
Sylvia Brandt, PhD[3]
Andrew Barenberg, PhD[4]

[1]Department of Health Promotion and Policy, University of Massachusetts-Amherst
[2]Ramboll-Environ, Amherst, Massachusetts
[3]Center for Public Policy and Administration, University of Massachusetts-Amherst
[4]Department of Economics, University of Massachusetts-Amherst

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The Cost of Basic Combat Training Injuries in the U.S. Army:
Injury-Related Medical Care and Risk Factors

Technical Report

Contents

Executive Summary

Purpose:

The purpose of this project was to use data from the Total Army Injury and Health Outcomes Database (TAIHOD) to analyze the direct medical costs to the Army of injuries occurring during Basic Combat Training (BCT) and to identify factors associated with injuries having the greatest impact on the Army. The specific project objectives were as follows: 1) Identify injuries and associated medical care and costs, 2) identify BCT injuries with substantial impact on the Army, and 3) identify risk factors for BCT injuries with substantial impact on the Army.

Methods:

A cohort of 333,347 apparent first-time trainees (83.4% men, 16.6% women) who started BCT between January 1, 2002 and September 30, 2007 was identified. The injury ascertainment period for each trainee began with the estimated start of BCT and lasted until the end of the month during which training ended. Medical encounter data from the Military Health System Data Repository (MDR) were used to identify trainees who sustained an injury during BCT. Injury-related medical encounters were identified using primary or secondary International Classification of Diseases (ICD-9) diagnosis and/or procedure codes.

Total direct medical cost per trainee was calculated by summing the costs of inpatient and outpatient care. Injury related medical costs were estimated using an incremental cost analysis whereby medical costs of injured trainees were compared to medical costs of uninjured trainees, controlling for the effects of sociodemographic characteristics, anthropometric characteristics, accession characteristics, and training location using multiple regression. The total direct cost to the Army of BCT-related injuries was estimated by multiplying the gender-specific adjusted mean incremental cost of injury by the gender-specific injury incidence, and then summing across genders.

Three outcomes were selected for further analysis in order to identify risk factors for injuries having a substantial impact on the Army: 1) a dichotomous indicator of any injury occurrence, 2) a continuous measure of total direct cost of medical care per trainee, and 3) a dichotomous indicator of high-cost injury, defined as an injury resulting in direct medical costs greater than $10,000 per trainee or an injury necessitating inpatient care.

Results:

Among the entire cohort, 43.04% had at least one injury-related medical encounter during BCT (n=143,459), comprising 39.48% (n=109,760) of men and 60.95% (n=33,705) of women. The same nine primary diagnoses were associated with the highest numbers of medical encounters for both men and women, though their rankings differed by gender. The most common reason for medical encounters for both men and women was “pain in joint, lower leg”, accounting for approximately 15% of injury visits. Other common diagnoses were “pain in limb,” “pain in joint, ankle & foot,” “sprain of ankle, unspecified,” “backache, unspecified,” “low back pain,” “sprains and strains of unspecified site of knee and leg,” “joint pain, shoulder,” and “pain in joint, pelvic region and thigh.”

For both men and women, older age, white race/ethnicity, lower educational attainment, being married or divorced vs. single, lower pay grade, and scoring lower on the Armed Forces

Qualification Test (AFQT) were independently associated with increased injury risk. Accession waivers, which were used as a proxy for pre-existing injury, were associated with increased risk of injury for men, but this association was not clear for women. Injury risk varied by training location. For men, training at Fort Benning was associated with higher injury risk than training at any of the other four locations. For women, training at Fort Leonard Wood was associated with higher injury risk than training at Fort Jackson.

Overall, the Army spent an average of approximately $1200 on medical care per trainee over the study period. Injury status was the single largest predictor of direct medical costs. The mean medical cost per injured trainee was $1755.00, compared to $794.60 per non-injured trainee. Thus, for each injured trainee, the Army spent an additional $960.40, on average. After adjusting for other factors that affect costs, the mean additional cost of injury was estimated to be $872.20 ($1093.70 for women, $825.90 for men). These additional costs of injury amounted to a total of $127,507,380 for the entire study period, or $21,929,700 per year.

Mean medical costs were higher for women than men, but predictors of cost were similar for men and women. Controlling for other factors that affect costs, increased costs were associated with older age, white race/ethnicity, lower educational attainment, and higher BMI, for both men and women. Medical costs were also higher for married and divorced women than for single women, but marital status did not significantly affect medical costs for men. Having a medical waiver at accession was not statistically significantly associated with medical costs during BCT for men or women.

Of the ten most common injury diagnoses, “physical therapy necessary” had the highest overall mean costs, at $2522.30 per trainee, followed by “pain in joint, pelvis & thigh,” at $2512.60 per trainee. Over all injuries, Fort Benning had the lowest mean costs ($1566.50 per injured trainee) and Fort Jackson had the highest mean costs ($1916.40 per injured trainee). Less than 1% of trainees sustained high-cost injuries. A total of 2641 trainees (0.79%) had total direct medical costs over $10,000, and 736 trainees (0.22%) required inpatient care.

Conclusions and Recommendations:

BCT-related injuries impose enormous economic costs on the U.S. Army. Approximately 40% of men and 61% of women sustained BCT-related injuries from 2002 to 2007. The most common types of injuries were sprains, strains, joint pain, and back pain. For each injured trainee, the Army incurs an estimated $872 in additional direct medical costs, which amounts to approximately $22 million annually.

While the Army’s current administrative data systems make this type of Army-wide analysis possible, these systems would be more useful for research purposes if they recorded BCT start and end dates for all trainees, trainee characteristics such as physical fitness and smoking, and information about injury severity. Data documentation must also be improved to facilitate research.

An in-depth study of the training environments and attitudes about injury in each of the five training sites is needed to fully understand the reasons for variation in medical costs across training locations. If further research identifies specific factors that contribute to increased costs at certain locations, opportunities for reducing costs could be identified.

Part 1:

Background and project overview

Injuries in Army Basic Combat Training

Physical training related injuries have been identified as a major threat to the readiness of the U.S. Armed Forces and a high priority for injury prevention. One of the earliest, most comprehensive studies of injuries in the U.S. military, *Injuries in the Military: A Hidden Epidemic* (Directorate of Epidemiology and Disease Surveillance, 1996), concluded that injuries, particularly those sustained during training, have a greater impact on military health and readiness than any other type of medical complaint. In a more recent examination of the most important and most preventable injury problems facing the U.S. Department of Defense, the Military Training Task Force identified physical training as the top priority for the military as a whole (Jones, Canham-Chervak et al., 2010). In a study incorporating estimates of limited duty days and service-specific data on injuries (Ruscio, Jones et al., 2010), physical training was again identified as a leading cause of injury in the military, and was ranked as the number one priority for the Army specifically.

Prevention of injuries during basic combat training (BCT) is of particular importance. Prior estimates indicate approximately one quarter of male U.S. Army trainees and approximately half of female Army trainees experience an outpatient-treated musculoskeletal injury during an eight-week period (Kaufman, Brodine et al., 2000). Prior research also indicates that trainees who are injured are three times more likely to be discharged from service during BCT than those who are not injured (Knapik, Canham-Chervak et al., 2001). While these studies provide evidence of a large impact, they do not capture the full burden of BCT injuries to the U.S. Army. Injuries are costly to treat and result in lost productivity. Prior studies have not attempted to enumerate the economic cost of BCT-related injuries service-wide in the U.S. Army.

Project Purpose and Objectives

The purpose of this project was to use data from the Total Army Injury and Health Outcomes Database (TAIHOD) to analyze the direct medical costs to the Army of injuries occurring during Basic Combat Training (BCT) and to identify factors associated with injuries having the greatest impact on the Army. The TAIHOD, maintained by the Military Performance Division of the U.S. Army Research Institute of Environmental Medicine (USARIEM), contains administrative data collected through several different Army data systems, including the Defense Manpower Data Center (DMDC), the Military Entrance Processing Command (MEPCOM), the Verification of Military Experience and Training (VMET) databases, the Military Health System Data Repository (MDR), and others. This project involved close collaboration between investigators from the University of Massachusetts-Amherst (UMass), Ramboll Environ, and USARIEM. The protocol

for this project was approved by the Institutional Review Boards of UMass and Ramboll Environ, and by the Human Use Review Committee at USARIEM.

This project was completed under two separate contracts. Work completed under the first contract identified and described a basic training cohort from the TAIHOD data (Sulsky et al., 2014) and identified likely risk factors for injury during BCT though a systematic review of the literature (Bulzacchelli et al., 2014). This report presents work completed under the second of the two contracts (Contract # W81XWH-13-C-0150). Under this contract, the project objectives were as follows:

Objective 1: Identify injuries and associated medical care and costs. To accomplish this objective, data from the Military Health System Data Repository (MDR) were linked to data from the DMDC, MEPCOM, and VMET so that medical encounters could be analyzed by trainee characteristics. An algorithm was developed for identifying injury-related medical care delivered during the appropriate risk period for each trainee. Injuries were categorized according to nature of injury and affected body region. Direct medical care costs related to injuries were estimated using an incremental cost analysis which compared total medical costs for injured trainees to total medical costs for non-injured trainees. Descriptive analysis summarized injuries, medical care, and costs by trainee and training characteristics. Part 2 of this report presents these analyses.

Objective 2: Identify BCT injuries with substantial impact on the Army. This objective involved ranking injuries occurring during BCT in terms of frequency and resource utilization, and examining costs for different levels of medical care. These rankings were used to define injuries with substantial impact on the Army and informed the selection of outcomes for the risk factor analysis. Part 3 of this report presents the rationale for selection of outcomes for the regression models developed under Objective 3.

Objective 3: Identify risk factors for BCT injuries with substantial impact on the Army. To achieve this objective, epidemiological analyses were conducted to identify risk factors for three outcomes: 1) any injury occurrence (yes/no); 2) the cost of medical care; 3) high-cost injuries. For these analyses, a series of regression models were developed and tested. Covariates included sociodemographic and training-related factors. Part 4 of this report presents these analyses.

Part 5 of this report discusses the implications of the project's findings.

Part 2:

Deliverable 1: Descriptive analysis of injuries, medical care, and costs

Descriptive Summary of Injuries and Injury-related Medical Care during BCT

Methods

Data sources

The Total Army Injury and Health Outcomes Database (TAIHOD) was used to define a cohort of first-time trainees who started BCT between January 1, 2002 and September 30, 2007. Information from the U.S. Army Military Entrance Processing Command (MEPCOM) and the Verification of Military Experience and Training (VMET) databases was incorporated into the TAIHOD for this study in order to obtain details related to BCT dates and locations. Detailed descriptions of the data sets and the methods used to construct the cohort and estimating starting and ending dates of BCT are available elsewhere (Sulsky et al., 2014). Medical encounter data from the Military Health System Data Repository (MDR) were used to identify indications that injuries had occurred during BCT. MDR data include records from: 1) the Standard Inpatient Data Record (SIDR); 2) the Comprehensive Ambulatory/Professional Encounter Record (CAPER); 3) the Standard Ambulatory Data Record (SADR); 4) TRICARE Encounter Data – Institutional (TEDi) and TRICARE Encounter Data – Non-Institutional (TEDni); and 5) the Pharmacy Data Transaction Service (PDTS). Records from all sources were linked via unique study identifier (ID).

Definition of cohort and risk period

The injury ascertainment period for each trainee began with the estimated start of BCT and lasted until the end of the month during which training ended. Exact training end dates were not available. Therefore, the end of BCT was estimated by assigning the earliest of either the date of separation from the Army as recorded in the DMDC or the service end date from VMET, consisting of month and year, or, if no end date was recorded, the month and year occurring 70 days after the estimated start of BCT. This was meant to cover a risk period consisting of BCT, and excluding Advanced Individual Training (AIT), during which training activities may diverge by job type (military occupational specialty, MOS) and pay grade. It was also meant to include a sufficient interval following the conclusion of BCT, during which trainees might seek previously deferred care for injuries.

After all individuals who appeared to have started BCT within the study period were identified, the cohort was limited to apparent first-time trainees by excluding those with: 1) evidence of prior military service based on DMDC data; 2) evidence of previous BCT based on VMET or MEPCOM data; 3) records suggesting injuries treated in the Army medical system prior to the estimated BCT start date; and 4) records with implausible data (Figure 2.1).

Identification of injuries

Injury-related medical encounters were identified from the MDR using primary or secondary International Classification of Diseases (ICD-9) diagnosis codes (Appendix Table A1) and any of four ICD-9 procedure codes (Appendix Table A2), alone or in combination (Appendix Table A3). Each medical encounter generates a separate record in the MDR. A trainee was considered to have suffered an injury during BCT if there was a record of medical care with one or more of the designated injury diagnosis or procedure codes recorded during the defined injury ascertainment period (i.e., risk period). Unique, incident events were defined by the first injury-related record for each individual. Trainees could have had more than one unique injury, and could have multiple treatment episodes for each unique injury recorded during BCT. Pharmacy data were not used to identify injuries because therapeutic class codes do not offer specific enough information. For example, non-steroidal anti-inflammatory drugs can be used for relief of pain or fever reduction, and the pharmacy records do not differentiate between indications for a given prescription.

Three concepts were used to assess "focal" injuries, or those likely to be of greatest importance: 1) injury frequency, based on the number of occurrences of each injury-related diagnosis (primary and/or secondary diagnosis for each person) based on the first injury-related medical encounter for each trainee; 2) injuries affecting the largest numbers of individual trainees; and 3) injuries resulting in high utilization or system burden. More specifically, we identified the ten conditions affecting the largest number of trainees; the ten diagnoses repeated most often per person affected; and the ten diagnoses leading to the highest utilization (i.e., most number of visits overall). Among these, diagnosis codes for physical and occupational therapy were heavily represented. Therefore, when physical and occupational therapy codes were recorded in the primary diagnosis field, we instead used the secondary diagnosis code from the same record to identify the reason for the therapy.

Statistical analysis

Data are described using simple frequency distributions and cross-tabulations by injury status. Results of chi-squared statistics and t-tests for comparisons of categorical and continuously measured data, respectively, are reported for reference. Data management and analyses were conducted using SAS software, Version 9.3 of the SAS System for Windows (Copyright 2002-2010 SAS Institute Inc, Cary, North Carolina).

Results

Injury-related medical encounters

Based on DMDC, VMET and MEPCOM data, we identified 333,347 apparent first time trainees, 83.4% of whom were men and 16.6% of whom were women (Figure 2.1). From the initial library of 27,854,204 medical encounter records, we dropped records for excluded trainees, exact duplicate records and those with service dates outside of the injury ascertainment period, leaving 2,093,477 observations in the MDR dataset potentially relevant to care delivered during the injury ascertainment period (Figure 2.2).

Medical encounters for injury and non-injury related care are summarized in Table 2.1. The vast majority of trainees (94.19%) had had at least one medical encounter during BCT (260,566 men and 53,416 women trainees); only 5.81% of the cohort had no medical encounters during BCT. Among the entire cohort, 43.04% had at least one injury-related medical encounter during BCT (n=143,459), comprising 39.48% (n=109,760) of men and 60.95% (n=33,705) of women. In addition, 92.26% of trainees had medical encounters during BCT that apparently were not related to injuries. Injury-related medical encounters were identified by ICD-9 diagnosis codes for 43.03% of trainees, accounting for nearly all of the individuals injured (143,452 of 143,474) and 0.15% were identified based on injury-related ICD-9 procedure codes. Higher proportions of women than men had medical encounters for both injury and non-injury related care. Because injuries were more commonly experienced by women than men, all further analyses are stratified by gender.

Characteristics of injured trainees

Table 2.2 compares height, weight, age, and BMI measured on continuous scales of inches, pounds, years, and m/kg^2, respectively, for men and women with and without injury-related medical encounters during BCT. Except for weight among women, all differences between injured and non-injured trainees were statistically significant even though the point estimates were almost identical and certainly without clinical significance. For example, the mean (SD) weight for men with injuries was 171.20 (30.59) pounds, vs. 169.8 (28.80) pounds for men without injuries ($p<0.0001$). The difference in weight for women with and without injuries was not statistically significant (136.90 pounds vs. 136.70 pounds, $p=0.51$).

Likewise, comparisons of categorical data were nearly universally statistically significantly different between trainees with and without injuries, even when the distributions across categories were almost the same. The only comparison that was not statistically significantly different was between proportions of injured vs. not injured trainees with an injury-related medical encounter recorded prior to the estimated start of BCT. Because of the data processing rules applied to the MDR records, less than 0.05% of both groups (injured and non-injured) had such medical encounters, and the percentages were similar for men and women. The only comparison that differed by more than five percentage points, an arbitrarily selected criterion, was for injury status by training location among men: 34.5% of injured men vs. 26.7% of uninjured men were trained at Fort Benning, GA ($p<0.0001$, Table 2.3).

Most common diagnoses

The same nine primary diagnoses were associated with the highest numbers of medical encounters for both men and women, although the percentages of visits accounted for by each reason varied by gender (Figure 2.3a and Figure 2.3b). The most common reason for medical encounters for both men and women was “pain in joint, lower leg”, accounting for 14.7% of injury visits by men (n=44,111 encounters, Figure 2.3a) and 15.07% of injury visits by women (n=18,286 encounters, Figure 2.3b). The next two most common reasons for medical encounters for men were “pain in limb” and “pain in joint, ankle and foot”, accounting for 7.75% and 6.1% of injury visits, respectively (Figure 2.3a). Among women, “pain in joint, ankle and foot” accounted for 9.31% of visits, and “pain in joint, pelvic region and thigh” accounted for 7.76% of visits (Figure 2.3b).

Among men, “fitting and adjustment of orthopaedic devices” was the tenth most common reason for medical encounters, accounting for 1.84% of visits (Figure 2.3a); this code was not among the top 10 reasons for medical encounters for women. “Acute upper respiratory infections of unspecified site” was the tenth most common reason for medical encounters for women, accounting for 1.82% of medical encounters, but was not among the top 10 reasons for medical encounters for men (Figure 2.3b).

After removing physical therapy codes, the ten diagnoses affecting the largest numbers of trainees were nearly identical to the ten diagnoses leading to the largest numbers of visits. Diagnoses were not mutually exclusive; the same trainee can have different types of injuries, and two or more conditions could be recorded at the same visit (Figure 2.4a and Figure 2.4b).

Table 2.1: Counts of medical encounters for injury and non-injury related care during Army Basic Training

	Totals (%)	Men (%)	Women (%)
First time trainees	333,347 (100)	278,045 (83.4)	55,302 (16.6)
Trainees with ≥1 medical encounter	313,982 (94.2)	260,566 (93.7)	53,416 (96.6)
Trainees with ≥1 non-injury-related medical encounter	307,555 (92.6)	255,138 (91.8)	52.417 (94.8)
Trainees with ≥1 injury-related medical encounter	143,459 (43.0)	109,760 (39.5)	33,705 (61.0))
Identified by ICD-9 diagnosis code	143,452 (43.0)	109,749 (39.5)	33,703 (60.9)
Identified by ICD-9 procedure code	494 (0.15)	383 (0.14)	111 (0.20)

Table 2.2: Mean age, weight, height and body mass index (BMI) for apparent first time Basic Combat trainees by injury status and gender.

	Men					Women				
	Injured (N=109,760; 39.48%)		Not injured (N=168,285; 60.52%)			Injured (N=33,699; 60.94%)		Not injured (N=21,603; 39.06%)		
	N	**Mean (Std D)**	**N**	**Mean (Std D)**	**p-value****	**N**	**Mean (Std D)**	**N**	**Mean (Std D)**	**p-value****
Age (years)	109,760	21.1 (3.65)	168,285	20.6 (3.31)	<.0001	33,699	20.79 (3.71)	21,603	20.31(3.36)	<.0001
Weight (pounds)	109,474	171.2 (30.59)	167,758	169.8 (28.80)	<.0001	33,613	136.9 (21.16)	21,527	136.7 (20.20)	0.5109
Height (inches)	109,522	69.25 (2.75)	167,831	69.17 (2.7)	<.0001	33,629	63.98 (2.59)	21,537	64.03 (2.54)	0.0206
Body Mass Index (kg/m²)	109,474	25.04 (3.92)	167,757	24.91 (3.70)	<.0001	33,613	23.45 (2.96)	21,527	23.40 (2.81)	0.0306

*Satterthwaite chi-squared p-value

Table 2.3: Demographic and training related characteristics of apparent first-time Basic Combat trainees, by injury status and gender

	Men					Women				
	Injured (N=109,760; 39.48%)		Not injured (N=168,285; 60.52%)			Injured (N=33,699; 60.94%)		Not injured (N=21,603; 39.06%)		
Demographic/training characteristics	**N**	**%**	**N**	**%**	**p-value***	**N**	**%**	**N**	**%**	**p-value***
Race/ethnicity										
White	80,209	73.08	118,873	70.64	<.0001	19,215	57.02	11,379	52.67	<.0001
Black	12,422	11.32	20,400	12.12		8,078	23.97	5,581	25.83	
Hispanic	11,451	10.43	19,245	11.44		4,395	13.04	3,092	14.31	
Asian	4,454	4.06	7,778	4.62		1,400	4.15	1,078	4.99	
American Indian	1,103	1	1,807	1.07		560	1.66	437	2.02	
Other	121	0.11	177	0.11		50	0.15	35	0.16	
Unknown	0	0	5	0		1	0	1	0	
Body Mass Index (BMI) in kg/m²										
Underweight: BMI<18.5	2,805	2.56	3,510	2.09	<.0001	1,369	4.06	762	3.53	<.0001
Normalweight:18.5≤BMI<25	54,693	49.83	87,135	51.78		22,223	65.95	14,815	68.58	
Overweight: 25≤BMI<30	38,610	35.18	60,374	35.88		9,531	28.28	5,772	26.72	
Obese: BMI≥30	13,652	12.44	17,266	10.26		576	1.71	254	1.18	
Education level in years										
Less than 12	32,453	29.57	44,073	26.19	<.0001	7,304	21.67	4,342	20.1	<.0001
12	65,082	59.29	103,162	61.3		21,455	63.67	13,706	63.44	
13 or 14	7,084	6.45	11,402	6.78		3,022	8.97	1,923	8.9	
15 or 16	4,868	4.44	9,181	5.46		1,805	5.36	1,514	7.01	
Greater than 16	273	0.25	467	0.28		113	0.34	118	0.55	
BCT Location										
Fort Benning, GA	37,814	34.45	44,899	26.68	<0.0001	11	0.03	11	0.05	<0.0001
Fort Jackson, SC	19,983	18.21	40,053	23.8		19,870	58.96	13,050	60.41	
Fort Sill, OK	14,498	13.21	19,086	11.34		23	0.07	31	0.14	
Fort Leonard Wood, MO	13,760	12.54	24,662	14.65		10,536	31.27	5,969	27.63	
Fort Knox, KY	12,665	11.54	21,088	12.53		31	0.09	42	0.19	
Unknown	11,040	10.06	18,497	10.99		3,228	9.58	2,500	11.57	

Table 2.3, continued

	Men					Women				
	Injured (N=109,760; 39.48%)		Not injured (N=168,285; 60.52%)			Injured (N=33,699; 60.94%)		Not injured (N=21,603; 39.06%)		
Demographic/training characteristics	**N**	**%**	**N**	**%**	**p-value***	**N**	**%**	**N**	**%**	**p-value***
Injury-related medical encounter before BCT start date										
Yes	94	99.91	162	99.9	0.3666	48	99.86	45	99.79	0.0651
No	109,666	0.09	168,123	0.1		33,651	0.14	21,558	0.21	
Medical/Physical Accession Waiver										
Yes	7,008	6.38	9,710	5.77	<.0001	2,054	6.1	1,231	5.7	0.0541
No	102,752	93.62	158,575	94.23		31,645	93.9	20,372	94.3	
Start of BCT Year										
2002	15,490	14.11	24,390	14.49	<.0001	5,093	15.11	3,601	16.67	<.0001
2003	19,843	18.08	29,948	17.8		6,592	19.56	4,281	19.82	
2004	21,180	19.3	31,748	18.87		6,527	19.37	4,310	19.95	
2005	18,475	16.83	26,858	15.96		5,262	15.61	3,257	15.08	
2006	19,097	17.4	30,753	18.27		5,733	17.01	3,448	15.96	
2007	15,675	14.28	24,588	14.61		4,492	13.33	2,706	12.53	
Month BCT started										
January	11,564	10.54	15,996	9.51	<.0001	3,193	9.48	1,692	7.83	<.0001
February	8,817	8.03	11,645	6.92		2,784	8.26	1404	6.5	
March	8,523	7.77	10,576	6.28		2,216	6.58	1,229	5.69	
April	9,730	8.86	11,833	7.03		3,075	9.12	1,580	7.31	
May	9,530	8.68	12,991	7.72		2,780	8.25	1,734	8.03	
June	10,690	9.74	19,730	11.72		3,280	9.73	2,601	12.04	
July	11,574	10.54	21,323	12.67		3,704	10.99	2,829	13.1	
August	12,590	11.47	21,232	12.62		4,300	12.76	2,896	13.41	
September	10,078	9.18	17,041	10.13		3,285	9.75	2,233	10.34	
October	8,006	7.29	13,358	7.94		2,445	7.26	1,829	8.47	
November	7,228	6.59	10,746	6.39		2,227	6.61	1,401	6.49	
December	1,430	1.3	1,814	1.08		410	1.22	175	0.81	

Table 2.3, continued

	Men					Women				
	Injured (N=109,760; 39.48%)		Not injured (N=168,285; 60.52%)			Injured (N=33,699; 60.94%)		Not injured (N=21,603; 39.06%)		
Demographic/training characteristics	**N**	**%**	**N**	**%**	**p-value***	**N**	**%**	**N**	**%**	**p-value***
Year and Quarter BCT started										
2002 Quarter 1	1,113	1.01	1,784	1.06	<.0001	323	0.96	198	0.92	<.0001
2002 Quarter 2	5,671	5.17	8,150	4.84		1,731	5.14	1,226	5.68	
2002 Quarter 3	5,253	4.79	9,025	5.36		1,827	5.42	1,347	6.24	
2002 Quarter 4	3,453	3.15	5,431	3.23		1,212	3.6	830	3.84	
2003 Quarter 1	5,718	5.21	7,446	4.42		1,969	5.84	1,168	5.41	
2003 Quarter 2	5,091	4.64	7,373	4.38		1,625	4.82	1,001	4.63	
2003 Quarter 3	5,451	4.97	8,895	5.29		1,928	5.72	1,289	5.97	
2003 Quarter 4	3,583	3.26	6,234	3.7		1,070	3.18	823	3.81	
2004 Quarter 1	6,465	5.89	8,518	5.06		1,784	5.29	1,099	5.09	
2004 Quarter 2	5,896	5.37	8,363	4.97		1,842	5.47	1,192	5.52	
2004 Quarter 3	5,379	4.9	9,882	5.87		1,786	5.3	1,376	6.37	
2004 Quarter 4	3,440	3.13	4,985	2.96		1,115	3.31	643	2.98	
2005 Quarter 1	4,822	4.39	5,415	3.22		1,233	3.66	504	2.33	
2005 Quarter 2	4,214	3.84	6,468	3.84		1,267	3.76	788	3.65	
2005 Quarter 3	6,152	5.6	10,090	6		1,865	5.53	1,391	6.44	
2005 Quarter 4	3,287	2.99	4,885	2.9		897	2.66	574	2.66	
2006 Quarter 1	5,407	4.93	7,309	4.34		1,416	4.2	582	2.69	
2006 Quarter 2	4,805	4.38	7,654	4.55		1,462	4.34	915	4.24	
2006 Quarter 3	5,984	5.45	11,407	6.78		2,067	6.13	1,416	6.55	
2006 Quarter 4	2,901	2.64	4,383	2.6		788	2.34	535	2.48	
2007 Quarter 1	5,379	4.9	7,745	4.6		1,468	4.36	774	3.58	
2007 Quarter 2	4,273	3.89	6,546	3.89		1,208	3.58	793	3.67	
2007 Quarter 3	6,023	5.49	10,297	6.12		1,816	5.39	1,139	5.27	

*Pearson chi-squared p-value

Figure 2.1: Finalizing the cohort of apparent first-time Basic Combat trainees, accounting for medical data

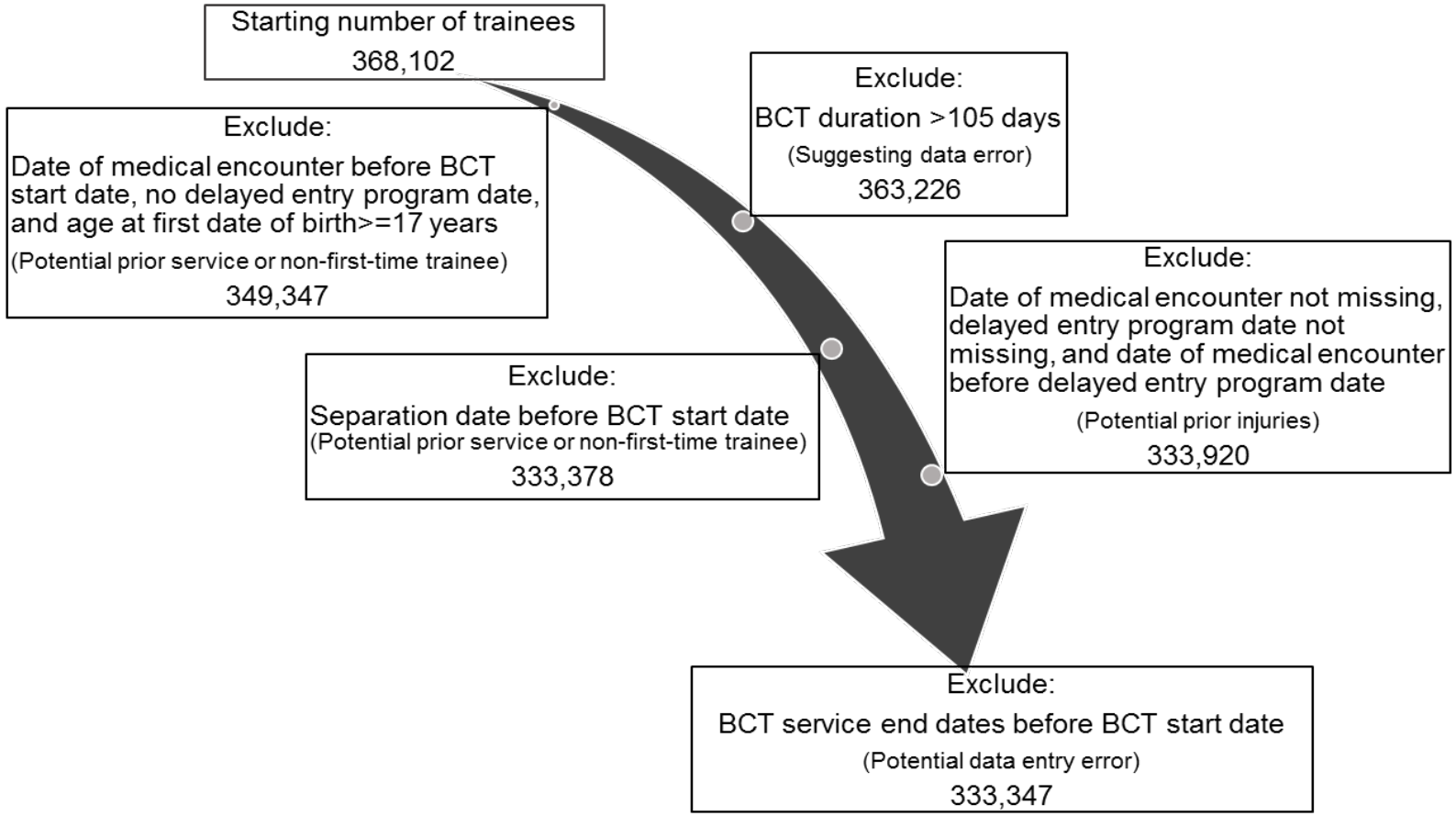


Figure 2.2: Handling of Medical Data Repository Records

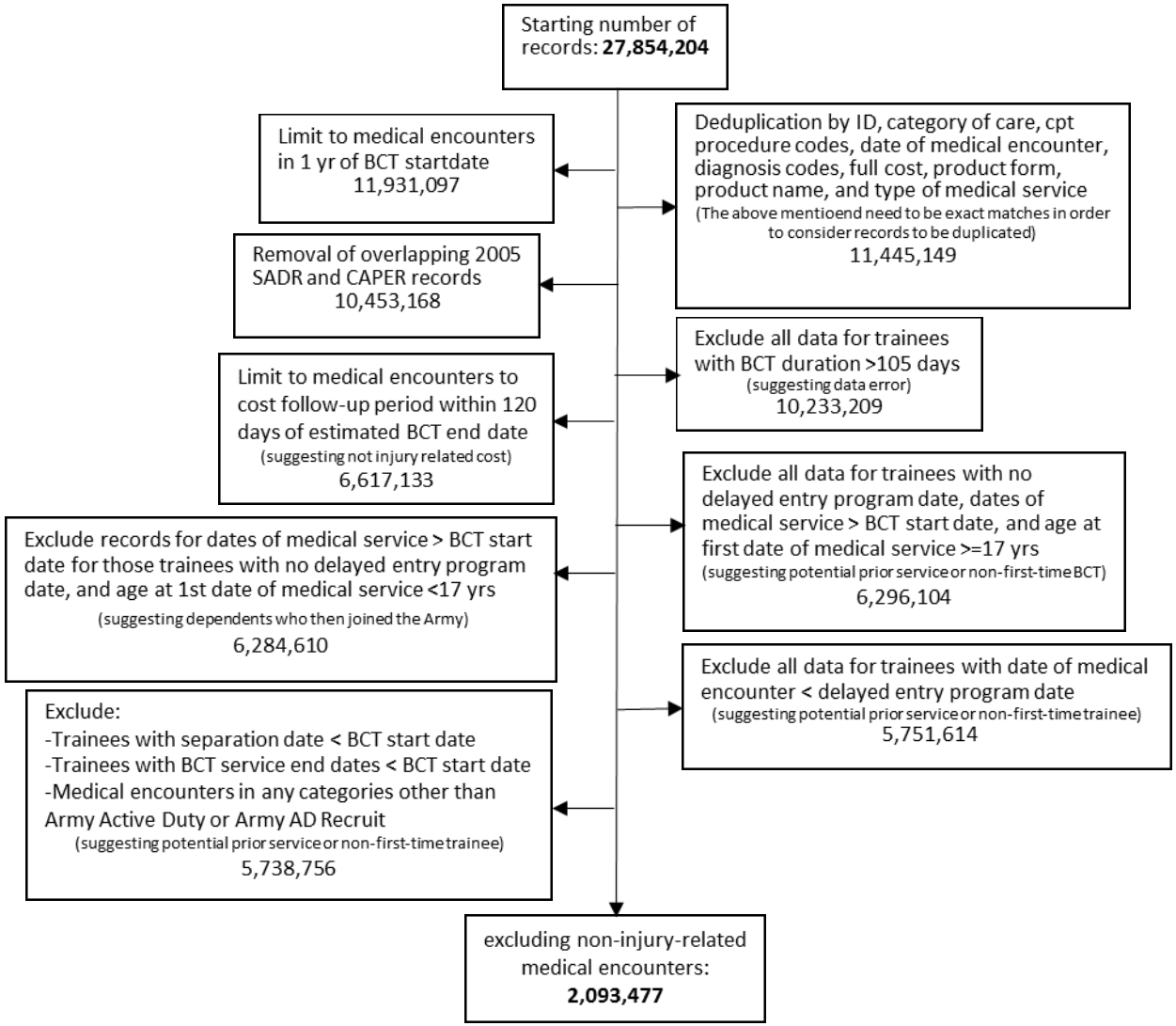


Figure 2.3a. Ten most common reasons medical encounters among men with injuries during BCT

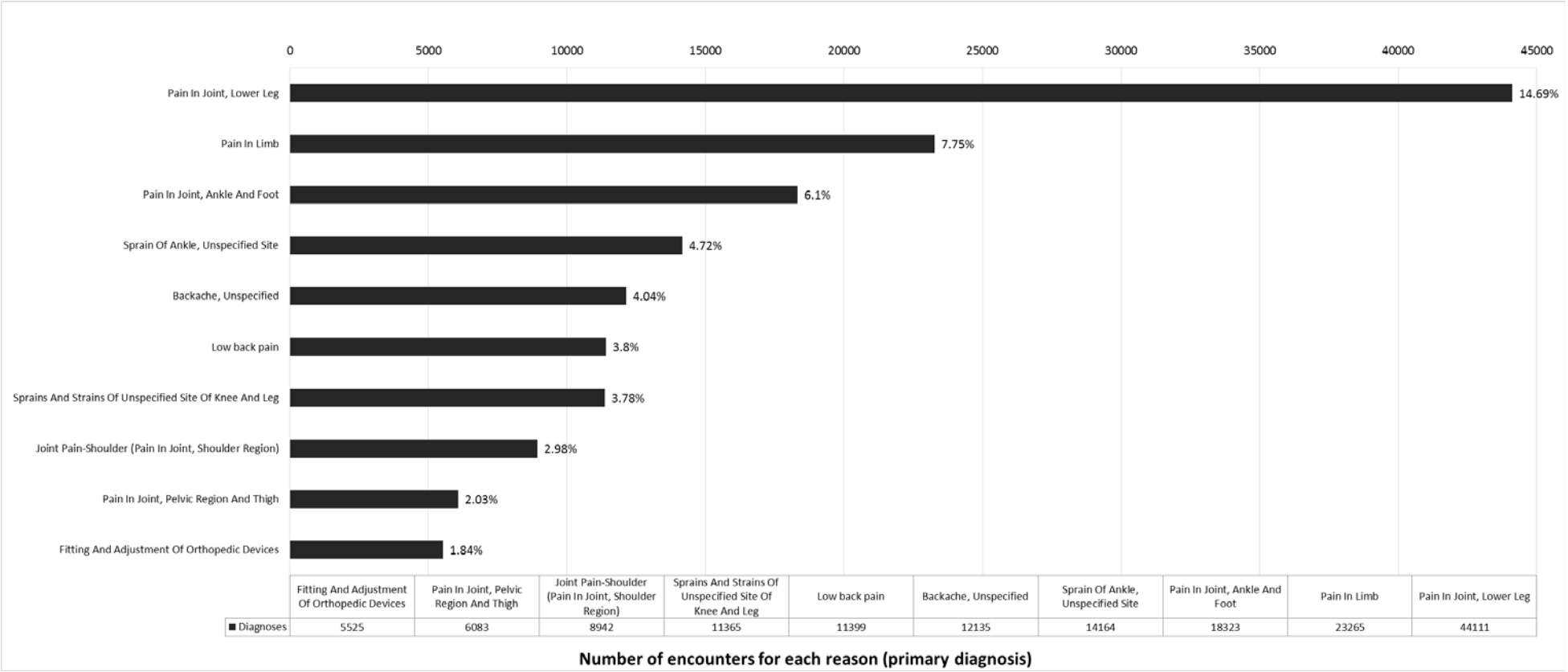


Figure 2.3b. Ten most common reasons for medical encounters among women with injuries during BCT

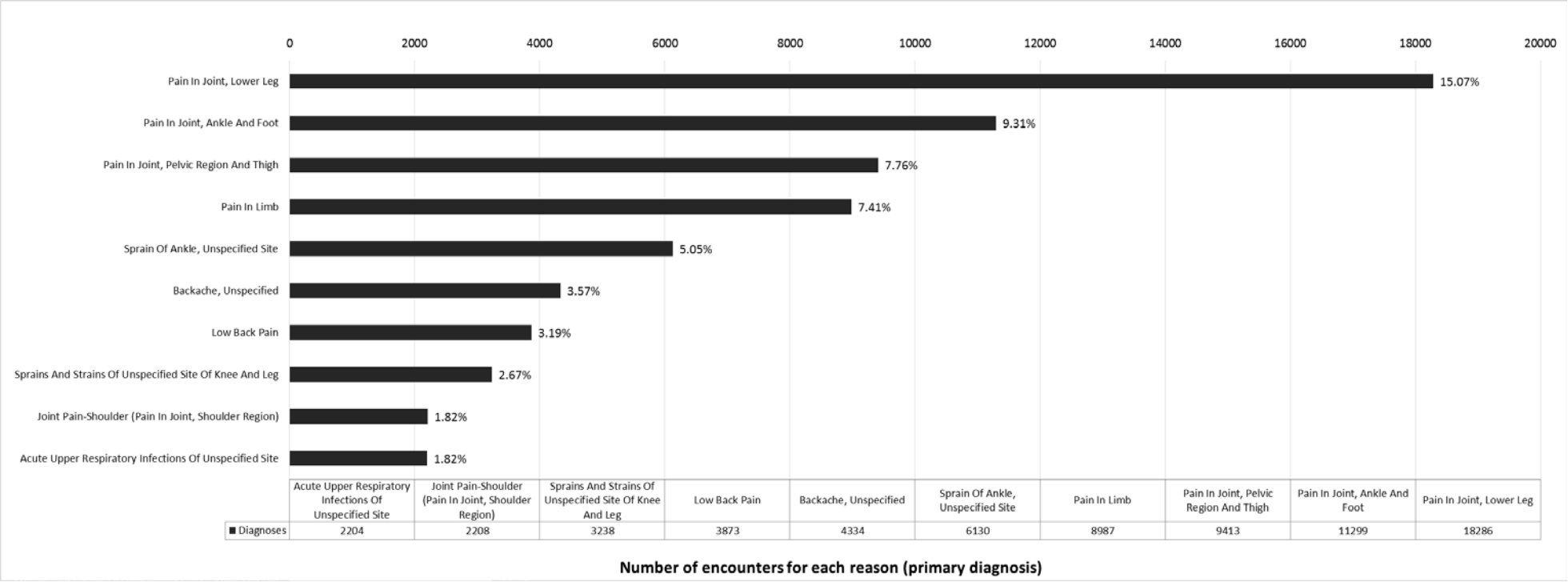
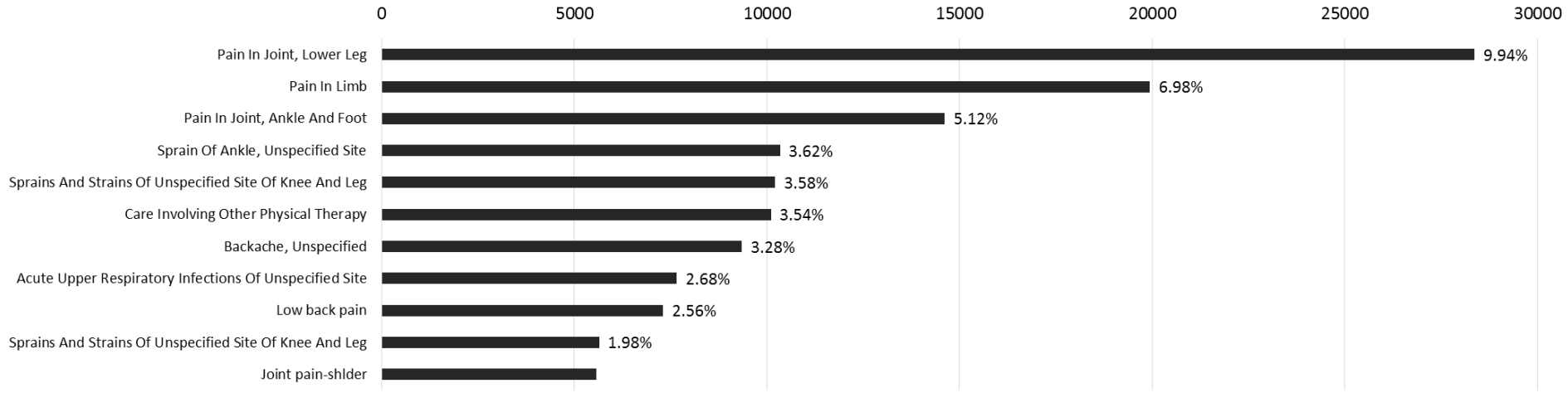
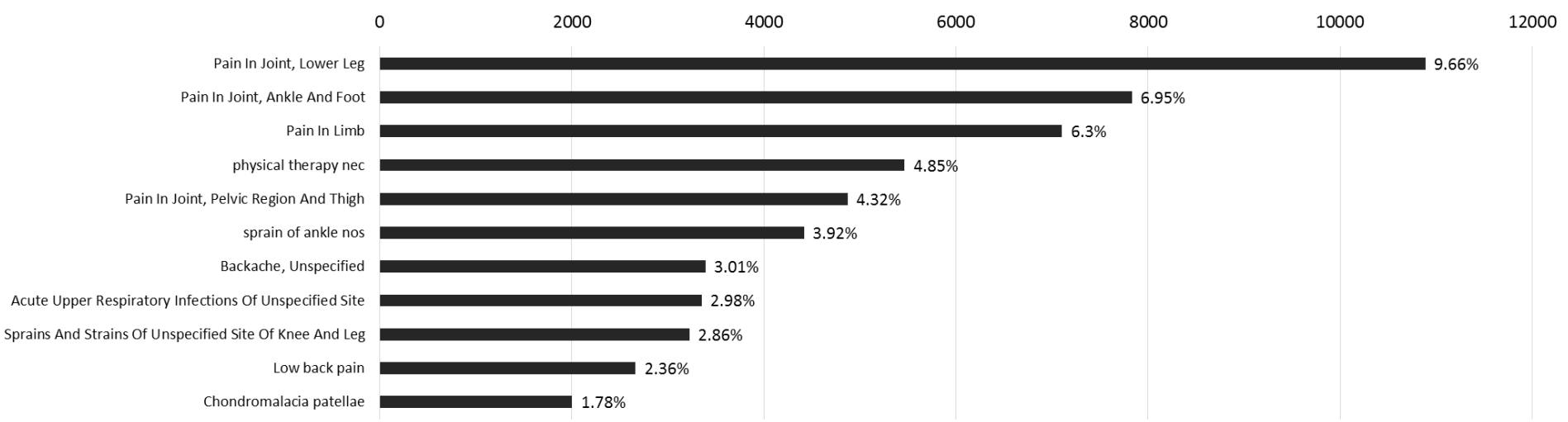


Figure 2.4a. Ten most common primary diagnoses: Men



	Joint pain-shlder	Sprains And Strains Of Unspecified Site Of Knee And Leg	Low back pain	Acute Upper Respiratory Infections Of Unspecified Site	Backache, Unspecified	Care Involving Other Physical Therapy	Sprains And Strains Of Unspecified Site Of Knee And Leg	Sprain Of Ankle, Unspecified Site	Pain In Joint, Ankle And Foot	Pain In Limb	Pain In Joint, Lower Leg
Diagnoses	5571	5647	7305	7660	9352	10107	10213	10342	14613	19933	28369

Figure 2.4b. Ten most common primary diagnoses: Women



	Chondromalacia patellae	Low back pain	Sprains And Strains Of Unspecified Site Of Knee And Leg	Acute Upper Respiratory Infections Of Unspecified Site	Backache, Unspecified	sprain of ankle nos	Pain In Joint, Pelvic Region And Thigh	physical therapy nec	Pain In Limb	Pain In Joint, Ankle And Foot	Pain In Joint, Lower Leg
■ Diagnoses	2002	2661	3225	3353	3392	4417	4871	5465	7103	7832	10887

Descriptive Summary of Medical Costs during BCT

Methods

Injury related medical costs were estimated using an incremental cost analysis. Specifically, medical costs of injured trainees were compared to medical costs of uninjured trainees, controlling for potential confounding variables using multiple regression. The difference in mean cost for an injured vs. uninjured trainee is the incremental cost of injury. This cost analysis used the same basic training cohort, ascertainment period, and medical encounters discussed above.

Outcome measure and data sources

The outcome of interest was the Army's total direct cost of medical care, defined as the medical care expenditures for diagnosis, treatment, and rehabilitation. Cost data were drawn from five data systems capturing different types of encounters. Records for each individual were linked over these sources of data using the unique study identifier (ID). All costs were converted to 2000 US dollars using the Consumer Price Index for All Urban Consumers (CPI-U). Costs for inpatient admissions were taken from the Standard Inpatient Data Record (SIDR). Cost of outpatient care data were taken from the Comprehensive Ambulatory/Professional Encounter Record (CAPER) and the Standard Ambulatory Data Record (SADR). The total amount paid by TRICARE, as reported in the TRICARE Encounter Data—Non-Institutional (TEDni) and Institutional (TEDi)—was added to the costs reported in SIDR and CAPER/SADR.

Total direct medical cost per trainee (total_cost) was calculated by summing the costs from each of these sources over the ascertainment period. Each data source has a different variable capturing costs (Table 2.4). Total cost is the sum of the variables "F_Cost," "t_paid," "fcdirect," and "paid."

Table 2.4. Cost variable names by data source

Data Source	Variable Name
CAPR/SADR	F_Cost
TDni	t_paid
SIDR	fcdirect
TEDi	paid

Pharmacy costs were not included in the total cost calculation because it was difficult to determine the actual expenditure on drugs from the Pharmacy Data Transaction Service (PDTS) data. However, recent research suggests that pharmaceuticals are likely to make up only a very small percentage of total direct medical expenditures for injuries. Prior studies estimate that pharmaceuticals account for between 2.4% (95% CI: 2.0, 2.9) and 3.0% (95% CI: 2.1, 4.2) of total direct medical costs of injuries among civilian workers in the U.S. (Shi, Wheeler, Lu, Bishai, Stallones, & Xiang, 2015; Xiang, Shi, Wheeler, Zhao, Wilkins III, & Smith, 2012). Excluding pharmacy costs therefore should not have a large effect on the incremental cost estimates produced here.

Main independent variable

The main independent variable for this analysis was injury status. The injury indicator variable developed for the epidemiologic analysis (described above) was used to identify injured vs. uninjured trainees.

Unadjusted incremental cost calculation

To calculate the additional costs attributable to an injury during training, the mean incremental cost of injury was calculated as the difference between the mean costs of those with an injury and the mean cost of those without an injury, as illustrated in the following equation, where M=total number of injured individuals and N=total number of non-injured individuals (Barnett and Nurmagambetov, 2011; Jo, 2014):

$$mean\ incremental\ cost_{unadjusted} = \left(\frac{\sum_{i=1}^{M} total\_cost_i}{M}\right)_{injured} - \left(\frac{\sum_{j=1}^{N} total\_cost_j}{N}\right)_{not-injured}$$

Mean incremental cost was calculated overall and separately for men and women because health care utilization for treatment of physical activity-related injury differs by gender (Kaeding, Borchers, Oman, & Pedroza, 2014). The unadjusted incremental cost does not account for factors other than injury status that can influence medical costs. Therefore, the unadjusted incremental cost was not used to estimate the total cost to the Army of BCT-related injuries.

Adjusted incremental cost calculation

To account for the effects of sociodemographic characteristics, anthropometric characteristics, accession characteristics, and training location on medical costs, an adjusted mean incremental cost of injury was calculated using multiple regression. The cost data were extremely right-skewed. Therefore, total cost per individual was first transformed using a natural logarithm, which resulted in normally distributed log-transformed cost data (Figure 2.5). Multiple linear regression was then performed, with the log-transformed total direct cost as the outcome and injury status as the predictor of interest. The analysis was stratified by gender, and covariates were selected based on their level of association with injury risk (discussed in Part 4 under Outcome 1). Specifically, covariates included BMI, age, race/ethnicity, marital status, education level, medical waiver at accession, and BCT location. The gender-specific adjusted cost estimates were used to estimate the total cost to the Army of BCT-related injuries, as described below.

Total cost calculation

The total direct cost to the Army of BCT-related injuries was estimated by multiplying the gender-specific adjusted mean incremental cost of injury by the gender-specific injury incidence, and then summing across genders (Box 2.1). Total cost was estimated for the entire study period and annually.

Descriptive statistical analysis

Mean total costs and mean incremental costs were calculated by injury status and gender. Mean total costs were also summarized by trainee characteristics (gender, BMI, age, race/ethnicity, marital status, education level, medical waiver, and training location). Lastly, mean total costs for the focal injuries described above (excluding the non-injury diagnoses) were calculated by training location. Specifically, mean costs, pooled for men and women, are presented by training location for joint pain in leg, physical therapy necessary, pain in limb, joint pain in ankle/foot, sprain of ankle, backache, sprain of knee & leg, joint pain in pelvis, lumbago, and joint pain in shoulder.

Figure 2.5. Distribution of log medical costs by injured status and gender

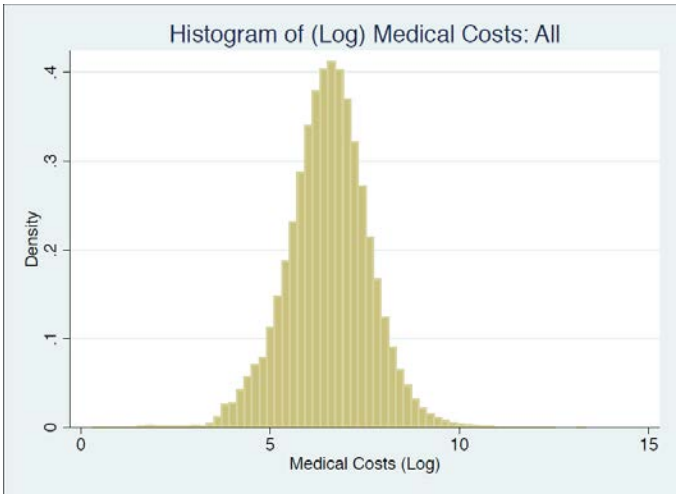


Figure 2.5a

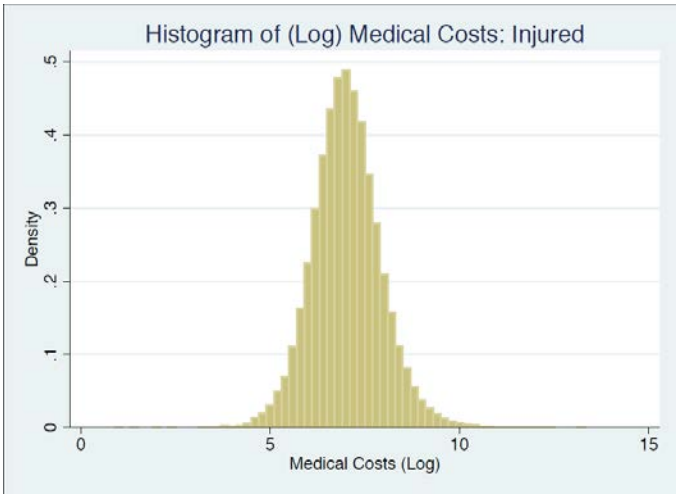


Figure 2.5b

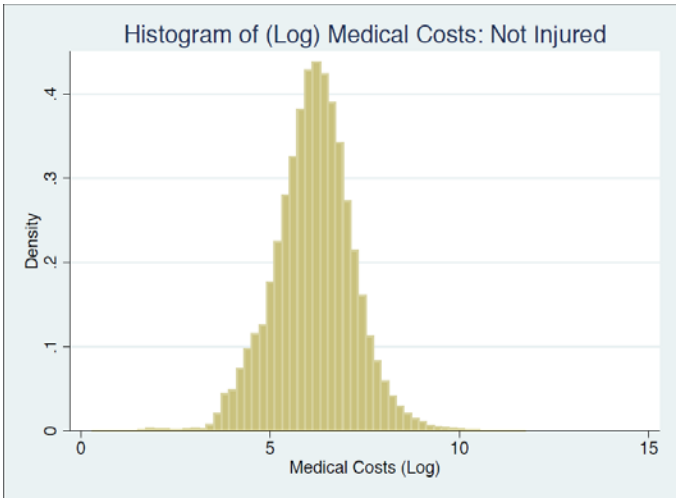


Figure 2.5c

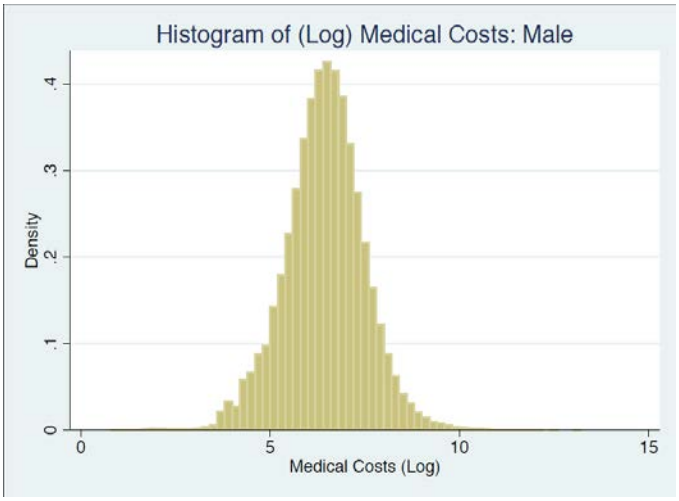


Figure 2.5d

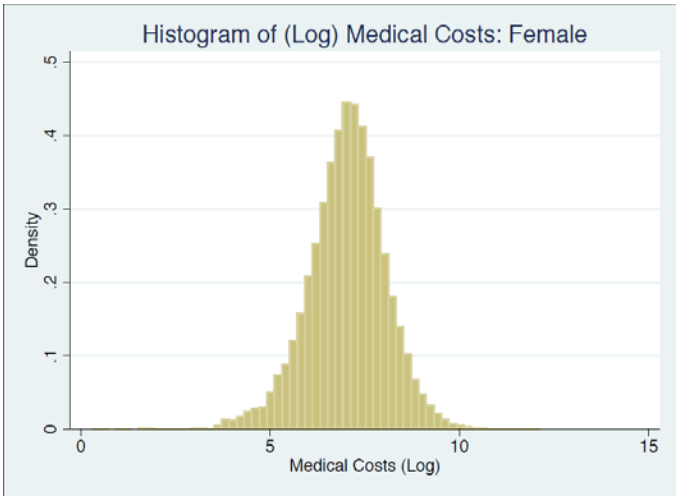


Figure 2.5e

Results

Unadjusted incremental cost

Overall, the mean total direct medical cost per trainee was $1207.90 (Table 2.5). Mean total cost differed by injury status, with costs being higher for injured trainees than non-injured trainees. The mean medical cost per injured trainee was $1755.00, compared to $794.60 per non-injured trainee. Thus, the overall unadjusted incremental cost of injury was $960.40.

Mean total cost differed by gender, with costs being higher for women than men (Table 2.5). The unadjusted mean cost per male trainee was $1085.80, compared to $1821.70 per female trainee. The incremental cost of injury also differed by gender. On average, injured males incurred costs $846.40 higher than non-injured males ($1598.10 per injured male vs. $751.70 per non-injured male), whereas on average, injured females incurred costs $1136.70 higher than non-injured females ($2265.80 per injured female vs. $1129.10 per non-injured female trainee).

Table 2.5. Summary of mean medical costs by gender and injured status, 2000 US dollars

	All (Injured & Non-Injured)	Injured	Not Injured	**Unadjusted Incremental Cost**	**Adjusted* Incremental Cost**
All (Both M & F)	1207.90	1755.00	794.60	**960.40**	**872.20**
Female	1821.70	2265.80	1129.10	**1136.70**	**1093.70**
Male	1085.80	1598.10	751.70	**846.40**	**825.90**
Difference (Female – Male)	735.90	667.70	377.40	**290.30**	**267.80**

*Adjusted for BMI, age, race/ethnicity, marital status, education level, medical waiver at accession, and BCT location

Adjusted incremental cost

After controlling for BMI, age, race/ethnicity, marital status, education level, medical waiver at accession, and BCT location, the adjusted incremental cost of injury was $872.20 overall (Table 2.5). The adjusted incremental cost of injury differed by gender, but slightly less so than the unadjusted incremental costs. For female trainees, the adjusted incremental cost of injury was $1093.70. For male trainees, the adjusted incremental cost of injury was $825.90.

Costs by trainee characteristics

Tables 2.6, 2.7, and 2.8 show unadjusted mean medical costs by trainee characteristics and injury status for all trainees, males, and females, respectively. Most patterns were similar for both genders. For both men and women, mean costs increased with increasing age, regardless of injury status. Also for both men and women, mean costs were highest for those with less than a high school education, those who were divorced, and those with a medical waiver at accession. Hispanics had the lowest mean costs of any racial or ethnic group (other than "unknown") for both men and women.

Patterns differed by gender for BMI and training location. For women, costs increased steadily with increasing BMI. However, for men, although costs were still highest for those with BMI > 30, the next highest costs were incurred by those with BMI < 18.5.

Of the five BCT locations that train men, the highest mean costs were in Fort Knox ($1233.60 per male trainee), and the lowest mean costs were in Fort Leonard Wood ($939.00 per male trainee). However, both BCT locations that train women had similar costs: $1821.60 per female trainee at Fort Jackson, and $1865.40 per female trainee at Fort Leonard Wood.

Costs by focal injury and training location

Of the ten most common injury diagnoses, the diagnosis with the highest overall mean cost was "physical therapy necessary" ($2522.30 per trainee), followed by "pain in joint, pelvis & thigh" ($2512.60 per trainee). The diagnoses with the lowest overall mean costs were "pain in joint, lower leg" ($1851.20 per trainee) and "sprain of ankle" ($1852.70 per trainee).

Mean costs varied by type of injury and training location (Table 2.9). The type of injury with the largest variation in mean cost across training locations was "backache, unspecified," for which the cost was lowest at Fort Sill ($2047.40 per trainee) and highest at Fort Knox ($2968.60 per trainee), a difference of $921.20 or 45%. The type of injury with the most consistent mean cost across training locations was "pain in joint, pelvis & thigh," for which the cost was lowest at Fort Sill ($2251.50 per trainee) and highest at Fort Leonard Wood ($2559.20 per trainee), a difference of $307.70 or 13.7%.

For injured trainees overall, Fort Benning had the lowest overall mean costs ($1566.50 per injured trainee), and Fort Jackson had the highest overall mean costs ($1916.40 per injured trainee). For trainees who were not injured, mean medical costs were very similar across training locations, ranging from $769.90 per uninjured trainee at Fort Leonard Wood to $826.70 per uninjured trainee at Fort Knox, a difference of only $56.80 or 7.4%.

Total cost estimates

Box 2.1 shows the calculation used to estimate the total cost to the Army of BCT-related injuries. The estimated total direct medical cost to the Army of BCT-related injuries for the entire study period is $127,507,380. The estimated annual direct medical cost to the Army of BCT injuries is $21,929,700.

Box 2.1

Calculation of estimated total cost to the Army of BCT-related injuries for entire study period

Total Cost	=	Adjusted Incremental Cost for Females	x	Number of Injured Females	+	Adjusted Incremental Cost for Males	x	Number of Injured Males
	=	$1093.70	x	33,699	+	$825.90	x	109,760
	=	$36,856,596.30 for females			+	$90,650,784.00 for males		
	=	$127,507,380.30						

Calculation of estimated annual cost to the Army of BCT-related injuries

Annual Cost	=	Adjusted Incremental Cost for Females	x	Mean Annual Number of Injured Females*	+	Adjusted Incremental Cost for Males	x	Mean Annual Number of Injured Males*
	=	$1093.70	x	5841.4	+	$825.90	x	18,817
	=	$ 6,388,739.18 for females			+	$15,540,960.30 for males		
	=	$21,929,699.50						

*The mean annual number of injuries is taken from complete years only (2002-2006)

Table 2.6. Mean medical costs, 2000 US dollars, males and females

	Not Injured	Injured	All
Total	794.60	1755.00	1207.90
BMI			
<18.5	794.60	1783.70	1283.40
18.5-25	794.00	1746.90	1203.80
25-30	789.50	1758.00	1197.50
>30	817.20	1779.70	1248.50
Age			
17-18	761.90	1716.00	1138.70
19-20	809.00	1739.80	1204.70
21-24	798.30	1729.70	1212.80
>25	838.40	1899.90	1365.70
Race			
Unknown	686.40	271.80	627.20
White	805.70	1792.00	1232.70
Black	822.80	1717.10	1217.20
Hispanic	727.80	1555.70	1071.40
Asian, Am Indian & Other	734.00	1788.10	1160.50
Marital Status			
Single	786.60	1725.10	1179.90
Married	833.90	1852.10	1320.20
Divorced	910.50	2113.80	1596.70
Education Level			
<High School	824.60	1826.00	1276.20
High School	791.70	1731.40	1191.50
>High School	749.10	1709.20	1143.60
Medical Waiver			
No Waiver	789.60	1750.10	1201.60
Medical Waiver	876.40	1827.30	1307.20
Training Location			
Fort Benning, GA	787.70	1566.50	1143.70
Fort Jackson, SC	814.00	1916.40	1286.60
Fort Sill, OK	823.80	1669.90	1189.10
Fort Leonard Wood, MO	769.90	1781.50	1217.40
Fort Knox, KY	826.70	1911.10	1233.60
Unknown & Other	737.80	1706.40	1129.80

Table 2.7. Mean medical costs, 2000 US dollars, males

	Not Injured	Injured	All
Total	751.70	1598.10	1085.80
BMI			
<18.5	745.00	1626.50	1136.60
18.5-25	738.70	1551.80	1052.20
25-30	753.20	1611.00	1087.80
>30	813.30	1741.60	1223.20
Age			
17-18	712.10	1541.40	1004.80
19-20	770.60	1586.70	1089.60
21-24	760.90	1584.90	1100.60
>25	786.70	1740.10	1228.00
Race			
Unknown	649.50	-	649.50
White	766.00	1640.00	1118.10
Black	753.20	1498.80	1035.40
Hispanic	690.80	1397.20	954.30
Asian, Am Indian & Other	694.20	1630.00	1038.40
Marital Status			
Single	746.60	1582.50	1069.60
Married	778.60	1655.10	1157.40
Divorced	807.50	1800.20	1309.10
Education Level			
<High School	792.20	1689.50	1172.70
High School	748.40	1572.30	1067.10
>High School	682.60	1493.30	980.40
Medical Waiver			
No Waiver	747.60	1593.10	1080.10
Medical Waiver	817.80	1671.70	1175.70
Training Location			
Fort Benning, GA	787.70	1566.50	1143.70
Fort Jackson, SC	711.70	1557.70	993.30
Fort Sill, OK	823.80	1669.90	1189.10
Fort Leonard Wood, MO	666.60	1427.20	939.00
Fort Knox, KY	826.70	1911.10	1233.60
Unknown & Other	704.10	1539.50	1016.40

Table 2.8. Mean medical costs, 2000 US dollars, females

	Not Injured	Injured	All
Total	1129.10	2265.80	1821.70
BMI			
<18.5	1023.20	2105.70	1718.60
18.5-25	1119.80	2227.20	1784.30
25-30	1168.90	2353.50	1906.70
>30	1081.60	2681.50	2191.90
Age			
17-18	1074.50	2167.50	1697.50
19-20	1140.90	2276.00	1836.10
21-24	1140.30	2269.90	1854.50
>25	1271.00	2466.10	2072.30
Race			
Unknown	870.90	271.80	571.30
White	1220.90	2426.60	1978.10
Black	1077.10	2052.80	1654.20
Hispanic	957.70	1968.70	1551.20
Asian, Am Indian & Other	984.40	2234.70	1690.30
Marital Status			
Single	1102.00	2215.60	1760.20
Married	1255.40	2400.90	2029.20
Divorced	1390.90	2656.80	2319.50
Education Level			
<High School	1153.40	2432.80	1955.80
High School	1117.80	2214.10	1786.70
>High School	1142.90	2243.30	1782.80
Medical Waiver			
No Waiver	1116.50	2259.70	1812.00
Medical Waiver	1338.10	2358.50	1976.10
Training Location			
Fort Jackson, SC	1127.90	2277.10	1821.60
Fort Leonard Wood, MO	1196.60	2244.30	1865.40
Unknown & Other	979.00	2266.10	1700.20

Table 2.9. Mean medical costs of focal injuries by training location, 2000 UD dollars, males and females

	All Locations	Fort Benning, GA	Fort Jackson, SC	Fort Sill, OK	Fort Leonard Wood, MO	Fort Knox, KY	Unknown/ Other	Difference Between Highest & Lowest $	Difference Between Highest & Lowest %
Total	1207.90	1143.70	1286.60	1189.10	1217.40	1233.60	1129.80	142.90	12.5
Not Injured	794.60	787.70	814.00	823.80	769.90	826.70	737.80	56.80	7.4
Injured	1755.00	1566.50	1916.40	1669.90	1781.50	1911.10	1706.40	349.90	22.3
Physical therapy necessary	2522.30	*2216.30*	2536.50	2762.20	**3011.50**	2424.40	2364.80	795.20	35.9
Pain in joint, pelvis & thigh	2512.60	2449.10	2555.90	*2251.50*	**2559.20**	2529.50	2373.60	307.70	13.7
Lumbago (low back pain)	2360.70	2206.90	**2557.10**	*2173.60*	2394.70	2499.00	2126.30	383.50	17.6
Backache, unspecified	2264.30	2225.00	2257.00	*2047.40*	2374.10	**2968.60**	2186.20	921.20	45.0
Joint pain-shoulder	2093.50	*1845.50*	2189.20	2047.20	2248.80	**2437.70**	2042.50	592.20	32.1
Pain in limb	2026.50	*1702.50*	**2266.00**	1958.50	2153.20	2198.40	1944.60	563.50	33.1
Pain in joint, ankle & foot	1964.40	*1674.10*	**2207.20**	1720.60	2026.70	2148.40	1894.70	533.10	31.8
Sprain/strain of knee & leg	1899.20	*1658.90*	**2092.80**	1999.30	1955.60	1968.10	1871.50	433.90	26.2
Sprain of ankle	1852.70	*1591.30*	**2094.70**	1883.50	1863.60	1756.90	1855.30	503.40	31.6
Pain in joint, lower leg	1851.20	*1593.30*	2026.80	1792.80	1891.90	**2079.00**	1792.40	485.70	30.5

Bold indicates highest mean cost for that type of injury, italics indicates lowest mean cost for that type of injury

Part 3:

Deliverable 2: Rationale for selection of outcomes for predictive models

Injuries impact the Army because they can affect warfighter readiness and can result in large medical costs. Three outcomes were selected for further analysis in order to identify risk factors for injuries having a substantial impact on the Army, either because of their frequency of occurrence or the medical costs associated with their treatment. The three outcomes, along with the rationale for their selection, are described below.

Outcome 1: Any injury occurrence

A dichotomous indicator for "any injury" occurrence (yes/no) was used as the outcome for the first predictive model because it casts the widest net, capturing injuries of any severity, frequency, and cause. This broad outcome is commonly used in injury research. Of the studies on risk factors for BCT-related injury reviewed in Bulzacchelli et al., 2014, 36.8% used "any injury" or "all injures" as at least one outcome. By our definition used in this study, any injury identified required at least one medical encounter and thus has some impact on the Army in terms of health care utilization. This outcome allows identification of individual characteristics and training factors associated with increased risk of any injury.

Outcome 2: Cost of medical care

Injuries can be costly to treat. A continuous measure of total direct medical cost per trainee was used as the outcome for the second predictive model. Because of the high frequency of certain injuries, even a modest increase in cost per injured trainee can add up to a substantial cost for the Army. Using total direct medical care cost as a continuous outcome allows identification of factors significantly associated with any increased cost.

Outcome 3: High-cost injuries

Some trainees sustain injuries that are extremely costly to treat. Although fewer in number, the high cost per injury means these cases have a substantial impact on the Army. These injuries are the focus of this analysis. A high-cost injury is defined here as an injury resulting in direct medical costs greater than $10,000 per trainee or an injury necessitating inpatient care. The $10,000 cut-off was determined by examining the frequency distribution of direct medical costs per trainee, which is extremely right-skewed. The inpatient care indicator was selected because of the implications of an inpatient stay for injury severity and intensity of health care resource utilization.

Part 4:

Deliverable 3: Predictive models of risk factors for injuries with substantial impact to the U.S. Army

Outcome 1: Any injury occurrence

Methods

For this analysis, the outcome was defined as the occurrence of at least one injury-related medical encounter recorded during the injury ascertainment period (i.e., any BCT-related injury, yes or no). Because the descriptive analyses clearly showed differences in risk of injury for men and women undergoing BCT, all subsequent analyses were completed separately by sex. We elected to use the split sample approach to build and validate the final predictive models. The training and testing data sets thus consisted of a 50% random sample of the cohort, drawn separately for men and for women (Dahl, Grotle, Saltyte Benth, & Natvig, 2008; Kleinbaum, Kupper, & Muller, 1988).

Using the training data sets, we completed preliminary analyses to calculate the Spearman (for categorical variables) and Pearson (for continuously measured variables) correlation coefficients for all pairs of demographic and training related variables included in the available data sets. Any pair of highly correlated variables ($r > 0.50$) was inspected and one member of the pair was selected for use in model building, based on the face validity of its potential association with injury.

To identify the initial set of covariates for the multivariable logistic regression model, we set up individual logistic regression models consisting of the outcome and each potential covariate. Because of the large sample size, traditional significance testing was not informative. Therefore, all covariates independently associated with at least 50% change from baseline risk (OR≥1.5 or ≤0.67) were retained in the first candidate multivariable model due to the apparent influence on risk. Covariates not associated with at least a 50% change in injury risk were excluded from the first candidate multivariable model, but we assessed their effect by adding each back into the model, one at a time. If the addition of any term resulted in at least 15% relative change in any regression coefficient ($\Delta\beta\% \geq 15$), that term was retained in the model. Finally, we estimated the log likelihood test to identify any term that did not materially affect the risk estimates (based on $\Delta\beta\%$) but that contributed information to the model based on statistical significance. Once the final set of covariates was identified, we assessed the sensitivity of the model to alternative parameterizations of height and weight. Specifically, we tested the effects of height, weight, BMI, and an indicator variable for unusual height defined as height above or below the sex-specific mean ± the sex-specific standard deviation for height, based on data for the whole cohort. We evaluated the contribution of each of these parameterizations as separate terms and in combinations determined by $\Delta\beta\%$ and the results of the log-likelihood test.

We performed the Hosmer and Lemeshow Goodness-of-Fit test on the final model, including alternatives based on sensitivity tests. We also estimated the positive and negative predictive values (PPV and NPV) for the final model and its alternatives and estimated the ability of the

model and its alternatives to discriminate between injured and non-injured trainees based on the area under ROC curves.

The final models for men and women were re-run in the respective testing sets, and all model diagnostics were repeated (Hosmer and Lemeshow Goodness-of-Fit tests, PPV and NPV, area under the ROC curves). We compared the estimated risks and results of all model diagnostics for models run on the training and testing data sets to assess the stability and validity of the model developed in the training data sets. Data management and analyses were conducted using SAS software, Version 9.3 of the SAS System for Windows (Copyright 2002-2010 SAS Institute Inc, Cary, North Carolina).

Results

The training and testing datasets returned near-identical results for point estimates, upper and lower 95% confidence intervals, and values for all model diagnostics. Therefore, all results are presented for the testing data set, which consisted of 139,020 men and 27,651 women. Similar to the cohort as a whole, 39% of men (n=54,784) and 61% of women (n=16,833) in the testing dataset sustained at least one injury during BCT (Table 4.1).

Bivariate Comparisons

All comparisons of categorized data for injured vs. non-injured trainees were statistically significantly different, even when the point estimates across categories were nearly the same for those with and without injury. A few comparisons differed by five or more percentage points, an arbitrarily selected criterion, as follows: Among men, 57% of those with medical care for injury during BCT were in enlisted grade 1 (E1), compared with 51.5% of those without injuries; 34.5% of the injured vs. 26.7% of the non-injured men trained at Ft. Benning, and 18.3% of the injured vs. 23.7% of the non-injured trained at Ft. Jackson. Graduation from BCT could not be confirmed for 53% of men with injuries during BCT, compared with 45% of men without injuries (Table 4.1).

Among women, using the same arbitrary criterion of five percentage points difference between injured and non-injured trainees, we found 57% of those with medical care for injuries during BCT were white, compared with 52% of those without injuries. Women treated for injuries during BCT were less likely to be single (77.9% vs. 84.4%), and more likely to be married (18.5% vs. 13.6%) compared to those without injuries. A smaller proportion of women whose graduation status was confirmed were injured during BCT, 71.7% compared with 78.6% of those without injuries (Table 4.1).

Among men, point estimates of age (in years), height (in inches), weight (in pounds), and body mass index (BMI) in units of kg/m^2 were nearly identical for those with and without injuries during BCT, but all comparisons were statistically significant. For example, the mean (SD) weight of men who experienced at least one injury during BCT was 171.1 (30.52) pounds, compared with 169.8 (28.85) pounds for those without injuries (Table 4.2). In contrast, only mean (SD) age was statistically significantly different for women who were injured, 20.80 (3.73) years vs. those who were not injured 20.30 (3.36) years; mean height, weight, and BMI were not statistically significantly different for the injured vs. non-injured women (Table 4.2).

Final Multivariable Model: Men

Sociodemographic characteristics

Adjusted odds ratios (OR) and 95% confidence intervals (95% CI) from the final multivariable model predicting risk of injury for men undergoing BCT are shown in Table 4.3. Categories of increasing age at entry into BCT[1] were monotonically associated with increases in odds of injury during BCT, such that men who were 19-20 years old had 18% higher odds of injury (OR=1.18, 95% CI: 1.15, 1.22), those who were 21-24 had 35% higher odds of injury (OR=1.35, 95% CI: 1.31, 1.40), and those who were $\geq$ 25 years old had 83% higher odds of injury (OR=1.83, 95% CI: 1.75, 1.91) compared with those who were 17-18 years old upon entering BCT.

Black men and those in the combined category of American Indian, Asian, or other race/ethnicity had slightly lower odds of injury compared with white men (OR=0.90 (95% CI: 0.85, 0.95) and OR=0.87 (95% CI: 0.84, 0.91), respectively). Hispanic men did not appear to have different odds of injury during BCT compared with white men (OR=1.01, 95% CI: 0.97, 1.04).

Men with less than 12 years of education had higher odds of injury during BCT compared with high school graduates (OR=1.20, 95% CI: 1.17, 1.23); additional education beyond high school did not appear to affect risk (OR=0.98, 95% CI: 0.94, 1.02).

Compared with E1, increasing pay grades at enlistment were associated with lower odds of injury during BCT: OR=0.84 (95% CI: 0.82, 0.87) for E2, OR=0.77 (95% CI: 0.74, 0.80) for E3, and OR=0.56 (95% CI: 0.53, 0.59) for the combined category of E4-E7.

Men who were currently married (OR=1.12, 95% CI: 1.09, 1.16) or formerly married (OR=1.36, 95% CI: 1.24, 1.49) had higher odds of injury than men who were single upon entry into BCT.

Anthropometric measures

For each unit increase in BMI, odds of injury increased slightly (OR=1.0, 95% CI: 1.0, 1.01), while men who were at least one standard deviation above or below the average height for the cohort had higher odds of injury than men who were of average height (OR=1.03, 95% CI: 1.0, 1.06 and OR=1.04, 95% CI: 1.01, 1.07, respectively).

Table 4.4 shows the results for alternative parameterizations of height and weight for men, adjusted for all other terms in the final model for men. After controlling for weight (in pounds), we found height (in inches), was marginally associated with odds of injury. Each one-inch increase in height was associated with a 1% increase in odds of injury during BCT (OR=1.01, 95% CI: 1.00, 1.01). In contrast, the point estimate and 95% confidence limits for the association between weight (in pounds) and injury during BCT were all 1.0. When we additionally controlled for BMI (kg/m^2), we found height and BMI both to be inversely associated with odds of injury (OR=0.93, 95% CI: 0.91, 0.96 for height, and OR=0.90, 95% CI: 0.87, 0.93 for BMI), while weight was positively associated with odds of injury during BCT (OR=1.02, 95%

[1] Categories defined by quintiles for men in the whole cohort

CI: 1.01, 1.02). In the final version of the model, we controlled for both BMI (kg/m^2) and unusual heights (mean $\pm$ 1 SD). In this model, none of the height and weight parameters was statistically significantly associated with odds of injury.

Training and accession characteristics

Compared to those trained at Ft. Benning, men trained at any of the other four BCT locations had lower odds of injury (or at least receiving medical care for an injury) during BCT, as follows: Ft. Jackson, OR=0.66 (95% CI: 0.64, 0.69); Ft. Knox, OR=0.69 (95% CI: 0.66, 0.72); Ft. Leonard Wood, OR=0.67 (95% CI: 0.65, 0.70); and Ft. Sill, OR=0.91 (95% CI: 0.88, 0.95). A sizeable proportion of trainees had an unknown or missing Unit Identification Code (UIC), or one not associated with one of the five BCT locations, in spite of other indications that they were first time trainees; these men also had lower odds of injury compared with those trained at Ft. Benning (OR=0.71, 95% CI: 0.68, 0.74).

There were differences in odds of injury during BCT for men whose training began during different time periods. The most common period for starting training was the third quarter of 2006, so we defined this interval as the referent period. All other periods (defined by calendar year and quarter) were associated with increases in odds of injury, with statistically significant increases ranging in magnitude from 14% in the third quarter of 2005 (OR=1.14, 95% CI: 1.07, 1.22) to 54% in the first quarter of 2005 (OR=1.54, 95% CI: 1.44, 1.66).

The Armed Forces Qualification Test (AFQT) is administered at accession into the Army, and standardized scores are calculated from four Armed Services Vocational Aptitude Battery subtests. The combined standardized scores are combined and reported as percentiles, with those scoring below the tenth percentile considered unqualified for Army service. We grouped the percentile scores into quintiles including a combined group for scores coded as unknown, missing or between the first and ninth percentiles. The most common scores were between the 31^{st} and 64^{th} percentile, and we used this as the referent group. Trainees with all other values of the AFQT percentile scores were at similar or somewhat lower odds of injury compared with the referent, with those scoring highest on the AFQT having the lowest odds of injury (and the only ones statistically significantly different than the referent). For men with scores in the 65^{th}-92^{nd} percentile, the OR was 0.95 (95% CI: 0.93, 0.98), and for men with scores in the 93^{rd}-99^{th} percentile, the OR was 0.93 (95% CI: 0.88, 0.97).

We evaluated accession waivers and MDR data with encounter dates preceding the estimated BCT start date to identify indications of pre-existing injury. Men without indications of prior injury-related medical care but with accession waivers granted for administrative reasons, only (OR=1.08, 95% CI: 1.04, 1.12), and those with accession waivers for medical or administrative reasons, or with indications of prior injury-related medical care (OR=1.10, 95% CI: 1.05, 1.15) had higher odds of injury that were of similar magnitude compared with men with no indication that they entered BCT with pre-existing injuries.

Final Multivariable Model: Women

Sociodemographic characteristics

Adjusted odds ratios (OR) and 95% confidence intervals (95% CI) from the final multivariable model predicting risk of injury for women undergoing BCT are shown in Table 4.5. Categories of increasing age at entry into BCT[2] were monotonically associated with increases in odds of injury during BCT, with women who were 19-20 years old at accession having 15% higher odds of injury (OR=1.15, 95% CI: 1.08, 1.22), those who were 21-24 having 38% higher odds of injury (OR=1.38, 95% CI: 1.28, 1.49), and those who were ≥25 years old having 61% higher odds of injury (OR=1.61, 95% CI: 1.45, 1.78) compared with those who were 17-18 years old at accession.

Black women, Hispanic women, and women in the combined category of American Indian, Asian, or other race/ethnicity had slightly lower odds of injury compared with white women (OR=0.78, 95% CI: 0.71, 0.87); OR=0.88 (95% CI: 0.82, 0.93); and OR=0.88 (95% CI: 0.81, 0.95), respectively.

Women with less than 12 years of education had higher odds of injury during BCT compared with high school graduates (OR=1.16, 95% CI: 1.08, 1.23); additional education beyond high school did not appear to affect risk (OR=0.94, 95% CI: 0.86, 1.03).

Compared with women in E1, increasing pay grades at enlistment were associated with lower odds of injury during BCT: OR=0.89 (95% CI: 0.84, 0.95) for E2, OR=0.85 (95% CI: 0.79, 0.91) for E3, and OR=0.60 (95% CI: 0.53, 0.69) for the combined category of E4-E7.

Women who were currently married (OR=1.27, 95% CI: 1.18, 1.37) or formerly married (OR=1.67, 95% CI: 1.40, 1.99) had higher odds of injury than women who were single upon entry into BCT.

Anthropometric measures

For each unit increase in BMI, odds of injury decreased slightly (OR=0.99, 95% CI: 0.98, 1.00), while women who were at least one standard deviation below the average height for the women in the cohort had higher odds of injury than women who were of average height (OR=1.11, 95% CI: 1.03, 1.19). Above average height was not associated with odds of injury for women (OR=1.00. 95% CI: 0.93, 1.07).

Table 4.6 shows the results for alternative parameterizations of height and weight for women, adjusted for all other terms in the final model for women. Compared to those who were of normal BMI (18.5 – 25 kg/m^2), we saw lower odds of injury for obese women (BMI $\geq$30 kg/m^2, OR=0.79, 95% CI: 0.69, 0.90) and underweight (BMI < 18.5 kg/m^2, OR=0.86, 95% CI: 0.75, 1.0) and higher odds of injury for women who were overweight (25 kg/m^2 ≤ BMI < 30 kg/m^2, OR=1.21, 95% CI: 0.94, 1.56). Because of its independent effects, evidenced by Δβ% and the results of the log-likelihood test, these results were also adjusted for height (in inches), which was inversely associated with injury risk. Each one-inch increase in height resulted in a statistically significant 2% decline in odds of injury (OR=0.98, 95% CI: 0.97, 0.99). In the second

[2] Categories defined by quintiles for women the whole cohort

alternative model, we included categories of BMI, and continuous measures of both height (inches) and weight (pounds). In this model, the decreased odds of injury for obese compared with normal weight women was slightly attenuated, but still present (OR=0.81, 95% CI: 0.69, 0.94), whereas other categories of BMI were no longer statistically significantly associated with odds of injury, and weight and height were marginally associated with injury risk. This version of the model is likely over-controlled. The final version of the model included BMI as a continuous covariate (kg/m^2) and indicators for women who were unusually tall (mean + 1 SD) or short (mean – 1 SD). In this model, BMI was not associated with odds of injury, but unusually short women had higher odds (OR=1.11, 95% CI: 1.04, 1.19) compared with women of average height. Heights at least one SD taller than average were not statistically significantly associated with odds of injury during BCT.

Training and accession characteristics

Compared to those trained at Ft. Jackson, women trained at Ft. Leonard Wood had higher odds of injury (OR=1.10, 95% CI: 1.04, 1.16). Women with unknown or missing Unit Identification Code (UIC), or one not associated with one of the three BCT training locations for women, had lower odds of injury compared with those trained at Ft. Jackson (OR=0.78, 95% CI: 0.72, 0.85).

Compared with the most common period for starting training, the third quarter of 2006, we noted non-statistically significant increases and decreases in odds of injury for women who started BCT at other times. Only three periods defined by calendar year and quarter were associated with statistically significant differences in odds of injury compared with the referent: OR=1.05 (95% CI: 1.26, 1.8) for women whose training began in the first quarter of 2005, OR=1.57 (95% CI: 1.33, 1.86) for women whose training began in the first quarter of 2006, and OR=1.24 (95% CI: 1.06, 1.46) for women whose training began in the first quarter of 2007.

Compared with women achieving the most common AFQT scores, between the 31st and 64th percentile, we noted that trainees with all other values of the AFQT percentile scores were at similar or somewhat lower odds of injury. Women who scored in the highest percentile category, the 93rd to 99th percentile, had the lowest odds of injury (OR=0.83, 95% CI: 0.72, 0.95). For women with scores in the 65th-92nd percentile, the OR was 0.92 (95% CI: 0.87, 0.97), and for women with scores in the 10thrd-30th percentile, the OR was 0.98 (95% CI: 0.83, 1.15). Women whose AFQT scores were unknown or missing, or at less than the 10th percentile, had the lowest odds of injury during BCT compared with the referent group, although the association was not statistically significant: OR=0.61 (95% CI: 0.35, 1.06).

Based on accession waivers and MDR data with encounter dates preceding the estimated BCT start date, we found indications of prior injury were inconsistently associated with odds of injury during BCT. Women without prior injury-related medical care but with accession waivers granted for administrative reasons had 12% higher odds of injury (OR=1.12, 95% CI: 1.00, 1.26), while those with accession waivers for medical or administrative reasons, or with indications of prior injury-related medical care, had no difference in odds of injury during BCT compared to women without prior injuries (OR=1.00, 95% CI: 0.90, 1.10).

Table 4.1. Demographic and training characteristics by injury: Testing data set

	Men (N=139,020) Injury in BCT					Women (N=27,651) Injury in BCT				
	Yes		No			Yes		No		
	N	%	N	%	p-value*	N	%	N	%	p-value*
Race/ethnicity										
White	40023	73.06	59644	70.81	<.0001	9642	57.11	5644	52.41	<.0001
Black	6238	11.39	10131	12.03		3979	23.57	2815	26.14	
Hispanic	5651	10.32	9633	11.44		2256	13.36	1542	14.32	
Am Indian, Asian, or Other	2872	5.24	4828	5.73		1006	5.96	767	7.12	
Education level in years										
Less than 12	16134	29.45	21975	26.09	<.0001	3715	22	2162	20.08	<.0001
12	32493	59.31	51698	61.37		10716	63.47	6888	63.97	
Greater than 12	6157	11.24	10563	12.54		2452	14.52	1718	15.95	
Marital Status										
Single, Never Married	45026	82.19	71991	85.46	<.0001	13143	77.85	9092	84.44	<.0001
Married	8685	15.85	11227	13.33		3125	18.51	1466	13.61	
Formerly married (annulled, separated, interlocutory, divorced, or widowed)	1013	1.85	944	1.12		589	3.49	194	1.8	
Unknown	60	0.11	74	0.09		26	0.15	16	0.15	

Table 4.1, continued

	Men (N=139,020) Injury in BCT					Women (N=27,651) Injury in BCT				
	Yes		No			Yes		No		
	N	%	N	%	p-value*	N	%	N	%	p-value*
Body Mass Index (BMI) in kg/m²										
Underweight: BMI<18.5	1443	2.63	1730	2.05	<.0001	713	4.22	397	3.69	0.001
Normal weight:18.5≤BMI<25	27288	49.81	43668	51.84		11174	66.18	7300	67.79	
Overweight: 25≤BMI<30	19316	35.26	30255	35.92		4714	27.92	2937	27.28	
Obese: BMI≥30	6737	12.3	8583	10.19		282	1.67	134	1.24	
Pay grade										
Enlisted 1	31266	57.07	43345	51.46	<.0001	9025	53.46	5279	49.02	<.0001
Enlisted 2	12405	22.64	20674	24.54		3798	22.5	2519	23.39	
Enlisted 3	8513	15.54	14957	17.76		3187	18.88	2208	20.51	
Enlisted 4, 5, 6, 7	2600	4.75	5260	6.24		873	5.17	762	7.08	
BCT Location										
Fort Benning, GA	18905	34.51	22450	26.65	<.0001	NA	NA	NA	NA	<.0001
Fort Jackson, SC	10016	18.28	19996	23.74		9926	58.79	6524	60.59	
Fort Sill, OK	7194	13.13	9558	11.35		NA	NA	NA	NA	
Fort Leonard Wood, MO	6794	12.4	12317	14.62		5314	31.48	2955	27.44	
Fort Knox, KY	6325	11.55	10613	12.6		NA	NA	NA	NA	
UIC Unknown, Missing, or Other	5550	10.13	9302	11.04		1643	9.73	1289	11.97	

Table 4.1, continued

	Men (N=139,020) Injury in BCT					Women (N=27,651) Injury in BCT				
	Yes		No			Yes		No		
	N	%	N	%	p-value*	N	%	N	%	p-value*
Start of BCT (Year)										
2002	7762	14.17	12361	14.67	<.0001	2563	15.18	1757	16.32	0.0066
2003	9964	18.19	14983	17.79		3275	19.4	2112	19.61	
2004	10551	19.26	15820	18.78		3272	19.38	2185	20.29	
2005	9218	16.83	13495	16.02		2641	15.64	1623	15.07	
2006	9436	17.22	15260	18.12		2901	17.18	1746	16.21	
2007	7853	14.33	12317	14.62		2231	13.21	1345	12.49	
Start of BCT (Month)										
January	5767	10.53	7926	9.41	<.0001	1544	9.15	840	7.8	<.0001
February	4298	7.85	5943	7.06		1392	8.24	724	6.72	
March	4197	7.66	5314	6.31		1130	6.69	596	5.53	
April	4842	8.84	5918	7.03		1532	9.07	763	7.09	
May	4771	8.71	6432	7.64		1383	8.19	866	8.04	
June	5359	9.78	9894	11.75		1657	9.81	1278	11.87	
July	5846	10.67	10667	12.66		1882	11.15	1404	13.04	
August	6392	11.67	10637	12.63		2150	12.73	1497	13.9	
September	5035	9.19	8493	10.08		1651	9.78	1126	10.46	
October	3894	7.11	6708	7.96		1248	7.39	907	8.42	
November	3632	6.63	5381	6.39		1118	6.62	687	6.38	
December	751	1.37	923	1.1		196	1.16	80	0.74	

Table 4.1, continued

	Men (N=139,020) Injury in BCT					Women (N=27,651) Injury in BCT				
	Yes		No			Yes		No		
	N	%	N	%	p-value*	N	%	N	%	p-value*
Start of BCT (Year, Quarter)										
2002 Quarter 1	524	0.96	902	1.07	<.0001	162	0.96	89	0.83	<.0001
2003 Quarter 1	2806	5.12	4086	4.85		864	5.12	595	5.53	
2004 Quarter 1	2684	4.9	4613	5.48		918	5.44	670	6.22	
2005 Quarter 1	1748	3.19	2760	3.28		619	3.67	403	3.74	
2006 Quarter 1	2824	5.15	3715	4.41		986	5.84	598	5.55	
2007 Quarter 1	2578	4.71	3656	4.34		788	4.67	479	4.45	
2002 Quarter 2	2793	5.1	4489	5.33		954	5.65	636	5.91	
2003 Quarter 2	1769	3.23	3123	3.71		547	3.24	399	3.71	
2004 Quarter 2	3166	5.78	4281	5.08		901	5.34	558	5.18	
2005 Quarter 2	2941	5.37	4117	4.89		931	5.51	598	5.55	
2006 Quarter 2	2718	4.96	4941	5.87		889	5.27	709	6.58	
2007 Quarter 2	1726	3.15	2481	2.95		551	3.26	320	2.97	
2002 Quarter 3	2405	4.39	2779	3.3		596	3.53	257	2.39	
2003 Quarter 3	2106	3.84	3272	3.88		638	3.78	399	3.71	
2004 Quarter 3	3081	5.62	4974	5.9		963	5.7	676	6.28	
2005 Quarter 3	1626	2.97	2470	2.93		444	2.63	291	2.7	
2006 Quarter 3	2653	4.84	3577	4.25		709	4.2	290	2.69	
2007 Quarter 3	2400	4.38	3816	4.53		753	4.46	469	4.36	
2002 Quarter 4	2975	5.43	5689	6.75		1038	6.15	726	6.74	
2003 Quarter 4	1408	2.57	2178	2.59		401	2.38	261	2.42	
2004 Quarter 4	2690	4.91	3929	4.66		712	4.22	368	3.42	
2005 Quarter 4	2141	3.91	3297	3.91		598	3.54	367	3.41	
2006 Quarter 4	3022	5.52	5091	6.04		921	5.46	610	5.66	

Table 4.1, continued

	Men (N=139,020)					Women (N=27,651)				
	Injury in BCT					Injury in BCT				
	Yes		No			Yes		No		
	N		%			N	%		p-value*	
AFQT score										
93% - 99%	3295	6.01	5729	6.8		546	3.23	434	4.03	
65% - 92%	19110	34.88	30315	35.99		4789	28.37	3203	29.75	
31% - 64%	30896	56.4	45800	54.37		11077	65.61	6795	63.1	
10% - 30%	1293	2.36	2026	2.41		420	2.49	290	2.69	
Unknown or missing or 1% - 9%	190	0.35	366	0.43		51	0.3	46	0.43	
					<.0001					<.0001
Confirmed Graduation										
No	29158	53.22	38024	45.14		4784	28.34	2308	21.43	
Yes	25626	46.78	46212	54.86		12099	71.66	8460	78.57	
					<.0001					<.0001
Pre-existing Injury										
Diagnosis or administrative or medical waiver	3576	6.53	4957	5.88		1054	6.24	658	6.11	
Administrative waiver but no diagnosis or medical waiver	6585	12.02	8529	10.13		1010	5.98	496	4.61	
No diagnosis or administrative or medical waiver	44623	81.45	70750	83.99		14819	87.77	9614	89.28	
					<.0001					<.0001

*Pearson p-value

Table 4.2. Mean (SD) age, height, weight, and body mass index by injury outcome: Testing data set

	Men					Women				
	Injured		Not injured			Injured		Not injured		
	N	Mean (Std)	N	Mean (Std)	p-value*	N	Mean (Std)	N	Mean (Std)	p-value*
Age (years)	54784	21.09 (3.66)	84236	20.59 (3.32)	<.0001	16883	20.80 (3.73)	10768	20.30 (3.36)	<.0001
Weight (pounds)	54646	171.1 (30.52)	83992	169.8 (28.85)	<.0001	16838	136.6 (21.13)	10731	137 (20.28)	0.1812
Height (inches)	54670	69.24 (2.75)	84033	69.18 (2.71)	<.0001	16844	63.97 (2.59)	10734	64.03 (2.55)	0.0622
Body Mass Index (kg/m^2)	54646	25.04 (3.91)	83991	24.90 (3.70)	<.0001	16838	23.43 (2.96)	10731	23.44 (2.81)	0.6099

*Satterthwaite p-value

Table 4.3: Adjusted odds ratios for injury during US Army Basic Combat Training: Men, 2002-2007 (n=139,020)[a]

Parameter	OR (0.95 CI)[b]
Age categories (years)	
17-18	1.00
19-20	1.18 (1.15, 1.22)
21-24	1.35 (1.31, 1.4)
≥25	1.83 (1.75, 1.91)
Race/ethnicity	
White	1.00
Black	0.90 (0.85, 0.95)
Hispanic	1.01 (0.97, 1.04)
American Indian, Asian, or Other	0.87 (0.84, 0.91)
Educational attainment (years)	
12	1.00
Greater than 12	0.98 (0.94, 1.02)
Less than 12	1.20 (1.17, 1.23)
Marital status	
Single, Never Married	1.00
Formerly married[d]	1.36 (1.24, 1.49)
Married	1.12 (1.09, 1.16)
Unknown	1.08 (0.76, 1.53)
BMI (kg/m^2)	1.00 (1, 1.01)
Height categories[c]	
Average Height	1.00
Unusually Short	1.03 (1, 1.06)
Unusually Tall	1.04 (1.01, 1.07)
Pay grade	
Enlisted 1	1.00
Enlisted 2	0.84 (0.82, 0.87)
Enlisted 3	0.77 (0.74, 0.8)
Enlisted 4, 5, 6, 7	0.56 (0.53, 0.59)
BCT location	
Fort Benning, GA	1.00
Fort Jackson, SC	0.66 (0.64, 0.69)
Fort Knox, KY	0.69 (0.66, 0.72)
Fort Leonard Wood, MO	0.67 (0.65, 0.7)
Fort Sill, OK	0.91 (0.88, 0.95)
UIC Unknown, Missing, or Other	0.71 (0.68, 0.74)

Table 4.3, continued

Parameter	OR (0.95 CI)[b]
Start of BCT (year and quarter)	
2006 Quarter 3	1.00
2002 Quarter 1	1.06 (0.94, 1.2)
2002 Quarter 2	1.29 (1.21, 1.38)
2002 Quarter 3	1.19 (1.12, 1.27)
2002 Quarter 4	1.18 (1.09, 1.27)
2003 Quarter 1	1.40 (1.31, 1.5)
2003 Quarter 2	1.33 (1.24, 1.43)
2003 Quarter 3	1.23 (1.15, 1.32)
2003 Quarter 4	1.06 (0.98, 1.14)
2004 Quarter 1	1.35 (1.26, 1.44)
2004 Quarter 2	1.34 (1.25, 1.43)
2004 Quarter 3	1.05 (0.98, 1.12)
2004 Quarter 4	1.28 (1.18, 1.38)
2005 Quarter 1	1.54 (1.44, 1.66)
2005 Quarter 2	1.22 (1.13, 1.31)
2005 Quarter 3	1.14 (1.07, 1.22)
2005 Quarter 4	1.15 (1.07, 1.25)
2006 Quarter 1	1.29 (1.2, 1.38)
2006 Quarter 2	1.16 (1.09, 1.25)
2006 Quarter 4	1.18 (1.08, 1.28)
2007 Quarter 1	1.21 (1.13, 1.29)
2007 Quarter 2	1.24 (1.15, 1.33)
2007 Quarter 3	1.17 (1.09, 1.24)
AFQT score at accession[e]	
31% - 64%	1.00
10% - 30%	0.99 (0.92, 1.07)
65% - 92%	0.95 (0.93, 0.98)
93% - 99%	0.93 (0.88, 0.97)
Unknown, missing or 1%-9%	0.84 (0.68, 1.03)

Table 4.3, continued

Parameter	OR (0.95 CI)[b]
Confirmed graduation	
No	1.00
Yes	0.80 (0.78, 0.82)
Indication of pre-existing injury	
No diagnosis or administrative or medical waiver	1.00
Administrative waiver but no diagnosis or medical waiver	1.08 (1.04, 1.12)
Diagnosis or administrative or medical waiver	1.10 (1.05, 1.15)

a. 383 observations were deleted due to missing values for the response or explanatory variables.

b. Odds ratios (OR) and 95% confidence intervals (95% CI) adjusted for all covariates shown in table.

c. Average height: Height between mean height-SD height and mean height+SD;
Unusually short: Height ≤ Mean height-SD height;
Unusually tall: Height ≥ Mean height+SD height.

d. Formerly married: annulled, separated, interlocutory, divorced, or widowed

e. AFQT scores are computed using the Standard Scores from four ASVAB subtests: Arithmetic Reasoning (AR), Mathematics Knowledge (MK), Paragraph Comprehension (PC), and Word Knowledge (WK), and reported as percentiles between 1-99. AFQT percentile score below 10% indicate failure to qualify for Army (http://official-asvab.com/index.htm).

Table 4.4: Adjusted[a] odds of injury during US Army Basic Combat Training with, different parameterizations for height and weight. Men, 2002-2007 (n=139,019)

	1:Adjusted for weight and height[a] OR (0.95 CI)	2:Adjusted for BMI, weight and height[a] OR (0.95 CI)	3:Adjusted for BMI and height flag[a,b] OR (0.95 CI)
BMI (kg/m^2)		0.90 (0.87, 0.93)	1.00 (1.00, 1.01)
Weight (pounds)	1.00 (1.00, 1.00)	1.02 (1.01, 1.02)	
Height (inches)	1.01 (1.00, 1.01)	0.93 (0.91, 0.96)	
Height categories[b]			
Average Height			1.00
Unusually Short			1.01 (0.98, 1.05)
Unusually Tall			1.08 (1.05, 1.11)

a. Adjusted for all demographic and training variables: age, race/ethnicity, educational attainment, marital status, pay grade, training location, training began annual quarter, AFQT score, confirmed graduation status, and indication of pre-training injury.

b. Average height: Height between mean height-SD height and mean height+SD;
Unusually short: Height ≤ Mean height-SD height;
Unusually tall: Height ≥ Mean height+SD height.

Table 4.5. Adjusted odds ratios for injury during US Army Basic Combat Training: Women, 2002-2007 (n=27,651)[a]

	OR (0.95 CI)[b]
Age category (years)	
17-18	1.00
19-20	1.15 (1.08, 1.22)
21-24	1.38 (1.28, 1.49)
≥25	1.61 (1.45, 1.78)
Race/ethnicity	
White	1.00
Black	0.78 (0.71, 0.87)
Hispanic	0.88 (0.82, 0.93)
American Indian, Asian, or Other	0.88 (0.81, 0.95)
Educational attainment (years)	
12	1.00
Greater than 12	0.94 (0.86, 1.03)
Less than 12	1.16 (1.08, 1.23)
Marital status	
Single, never married	1.00
Formerly married[c]	1.67 (1.40, 1.99)
Married	1.27 (1.18, 1.37)
Unknown	0.87 (0.45, 1.67)
BMI (kg/m^2)	0.99 (0.98, 1.00)
Height category[c]	
Average Height	1.00
Unusually Short	1.11 (1.03, 1.19)
Unusually Tall	1.00 (0.93, 1.07)
Pay grade	
Enlisted 1	1.00
Enlisted 2	0.89 (0.84, 0.95)
Enlisted 3	0.85 (0.79, 0.91)
Enlisted 4, 5, 6, 7	0.60 (0.53, 0.69)
BCT location	
Fort Jackson, SC	1.00
Fort Leonard Wood, MO	1.10 (1.04, 1.16)
UIC Unknown, Missing, or Other	0.78 (0.72, 0.85)

Table 4.5, continued

	OR (0.95 CI)[b]
Start of training (year and quarter)	
2006 Quarter 3	1.00
2002 Quarter 1	1.19 (0.90, 1.58)
2002 Quarter 2	0.94 (0.82, 1.09)
2002 Quarter 3	0.99 (0.86, 1.14)
2002 Quarter 4	1.03 (0.88, 1.21)
2003 Quarter 1	1.07 (0.92, 1.23)
2003 Quarter 2	1.10 (0.94, 1.27)
2003 Quarter 3	1.09 (0.95, 1.26)
2003 Quarter 4	0.89 (0.75, 1.05)
2004 Quarter 1	1.05 (0.91, 1.22)
2004 Quarter 2	1.01 (0.87, 1.16)
2004 Quarter 3	0.87 (0.76, 1.00)
2004 Quarter 4	1.11 (0.93, 1.31)
2005 Quarter 1	1.50 (1.26, 1.80)
2005 Quarter 2	1.08 (0.92, 1.27)
2005 Quarter 3	1.01 (0.88, 1.16)
2005 Quarter 4	0.94 (0.79, 1.13)
2006 Quarter 1	1.57 (1.33, 1.86)
2006 Quarter 2	1.10 (0.94, 1.28)
2006 Quarter 4	1.09 (0.90, 1.32)
2007 Quarter 1	1.24 (1.06, 1.46)
2007 Quarter 2	1.13 (0.96, 1.33)
2007 Quarter 3	1.06 (0.92, 1.22)
AFQT score at accession[d]	
31% - 64%	1.00
10% - 30%	0.98 (0.83, 1.15)
65% - 92%	0.92 (0.87, 0.97)
93% - 99%	0.83 (0.72, 0.95)
Unknown, missing or score 1%-9%	0.61 (0.35, 1.06)
Confirmed graduation	
No	1.00
Yes	0.71 (0.67, 0.76)
Indication of pre-existing injury	
No diagnosis or administrative or medical waiver	1.00
Administrative waiver but no diagnosis or medical waiver	1.12 (1.00, 1.26)
Diagnosis or administrative or medical waiver	1.00 (0.90, 1.10)

a. 82 observations were deleted due to missing values for the response or explanatory variables.

b. Odds ratios (OR) and 95% confidence intervals (95% CI) adjusted for all covariates shown in table.

c. Formerly married: annulled, separated, interlocutory, divorced, or widowed.

d. Average height: Height between mean height-SD height and mean height+SD;
Unusually short: Height ≤ Mean height-SD height;
Unusually tall: Height ≥ Mean height+SD height.

e. AFQT scores are computed using the Standard Scores from four ASVAB subtests: Arithmetic Reasoning (AR), Mathematics Knowledge (MK), Paragraph Comprehension (PC), and Word Knowledge (WK), reported as percentiles between 1-99. AFQT percentile score below 10% indicate failure to qualify for Army (http://official-asvab.com/index.htm).

Table 4.6. Adjusted[a] odds of injury during US Army Basic Combat Training with, different parameterizations for height and weight. Women, 2002-2007 (n=27,651)

	1:Adjusted for categorical BMI and height[a] OR (0.95 CI)	2: Adjusted for categorical BMI, weight and height[a] OR (0.95 CI)	3:Adjusted for BMI and height flag[a,c] OR (0.95 CI)
BMI (kg/m^2)			1.00 (1.00, 1.02)
BMI: Categorical[b]			
Normal Weight	1.00	1.00	
Obese	0.79 (0.69, 0.90)	0.81 (0.69, 0.94)	
Overweight	1.21 (0.94, 1.56)	1.32 (0.95, 1.83)	
Underweight	0.86 (0.75, 1.00)	0.91 (0.75, 1.11)	
Weight (pounds)		0.99 (0.97, 1.00)	
Height (inches)	0.98 (0.97, 0.99)	1.00 (1.00, 1.00)	
Height Flag[c]			
Average Height			
Unusually Short			1.11 (1.04, 1.19)
Unusually Tall			0.95 (0.89, 1.02)

a. Adjusted for all demographic and training variables: age, race/ethnicity, educational attainment, marital status, pay grade, training location, start of training (year and quarter), AFQT score, confirmed graduation status, and indication of pre-training injury.

b. Normal weight: 18.5 ≤ BMI< 25 kg/m^2; Obese: BMI ≥ 30 kg/m^2; Overweight: 25 ≤ BMI < 30 kg/m^2; Underweight: BMI<18.5 kg/m^2

c. Average height: Height between mean height-SD height and mean height+SD;
Unusually short: Height ≤ Mean height-SD height;
Unusually tall: Height ≥ Mean height+SD height.

Figure 4.1: ROC curve, Men, 2002-2007 (n=139,020)

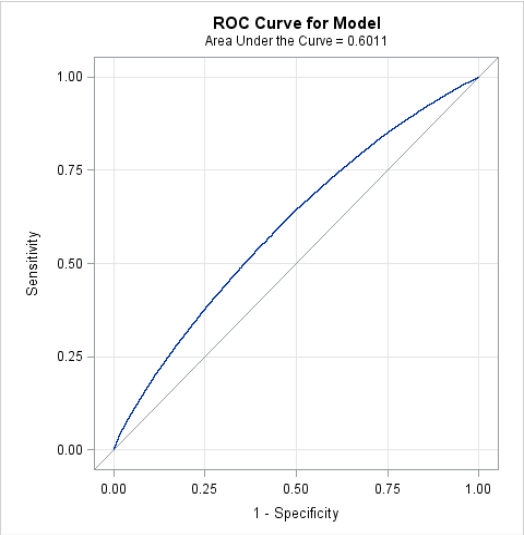
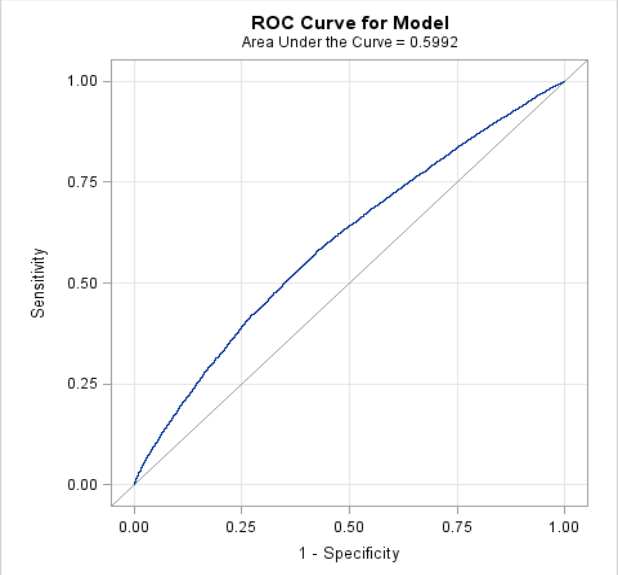


Figure 4.2: ROC curve, Women, 2002-2007 (n=27,651)



Outcome 2: Cost of medical care

Methods

The methods used in this analysis are described in Part 2 of this report, where the incremental cost analysis was first introduced. The regression model used to determine the adjusted incremental cost of injury discussed in Part 2 is presented here. Again, the outcome of interest was the total direct medical cost per trainee (total_cost), and the main independent variable was injury status. The analysis was stratified by gender, and covariates included BMI, age, race/ethnicity, marital status, education level, medical waiver at accession, and BCT location.

Results

Table 4.7 shows the results of this analysis. Injury status was the single largest predictor of medical costs. The adjusted incremental costs of injury discussed in Part 2 ($825.90 for men, $1093.70 for women) reveal that sustaining an injury is associated with medical costs roughly double those incurred in the absence of injury, after controlling for other factors that affect costs. This association is statistically significant ($p<0.001$) for both men and women. Factors that change costs by 10% or more of the adjusted incremental cost of injury (a change ≥ $82.59 for men or ≥ $109.37 for women) with p-values < 0.01, after controlling for all other factors in the model, are highlighted here.

Sociodemographic characteristics

Older age was associated with increased costs for both men and women. Compared to trainees age 17-18, trainees over age 25 had mean medical costs $160.50 higher for men ($p<0.001$) and $207.70 higher for women ($p<0.001$).

For both men and women, all race/ethnicity groups other than white were associated with decreased costs. The largest decreases were for Hispanic women (-$360.20, $p<0.001$), Black women (-$261.00, $p<0.001$), Asian/American Indian/Other women (-$239.70, $p<0.001$), and Hispanic men (-$137.20, $p<0.001$).

Compared to trainees with less than a high school education, those with at least a high school education experienced lower medical costs. The largest decreases in costs were for trainees completing more than high school: -$203.90 for women ($p<0.001$) and -$175.10 for men ($p<0.001$), on average. Medical costs were also substantially lower for women with only a high school education (-$139.0, $p<0.001$).

Compared to single women, married and divorced women had significantly higher medical costs, but only divorced women, with an increase of $252.30 ($p<0.001$), reached the 10% higher than adjusted incremental cost threshold. Marital status did not significantly affect medical costs for men.

Anthropometric measures

In general, higher BMI was associated with higher medical costs, but the difference was not statistically significant for all groups. Compared to men with a BMI of 18.5-25, men with a BMI > 30 had mean costs $101.10 higher ($p<0.001$). Compared to women with a BMI of 18.5-25, women with a BMI < 18.5 had mean costs $134.20 lower ($p<0.001$).

Training and accession characteristics

Medical costs varied by training location for men, but not for women. Compared to male trainees at Fort Jackson, costs were substantially higher for male trainees at Fort Knox ($212.50, $p<0.001$) and Fort Sill ($111.70, $p<0.001$). Medical costs were significantly lower for male trainees at Fort Leonard Wood (-$80.32, $p<0.001$), just under the 10% of adjusted incremental cost threshold. Having a medical waiver at accession was not significantly associated with medical costs during BCT for men or women.

Table 4.7. Additional medical costs of being injured, 2000 US Dollars

	Unadjusted			Adjusted		
	Male	Female	Pooled	Male	Female	Pooled
Constant	751.7***	1129.1***	794.6***	507.1***	1006.7***	479.1***
	(4.325)	(13.44)	(4.136)	(16.19)	(37.94)	(15.04)
Injured	846.5***	1136.7***	960.4***	825.9***	1093.7***	872.2***
	(11.22)	(21.84)	(9.836)	(11.28)	(21.81)	(10.05)
BMI						
< 18.5				20.96	-134.2**	-18.33
				(28.47)	(44.15)	(24.01)
25-30				31.99**	55.83*	35.77***
				(10.53)	(26.44)	(9.806)
> 30				101.1***	210.4	101.5***
				(17.12)	(155.3)	(17.17)
Age						
19-20				56.09***	93.26**	63.38***
				(13.41)	(30.15)	(12.24)
21-24				62.09***	70.26*	64.51***
				(14.66)	(34.40)	(13.44)
> 25				160.5***	207.7***	167.1***
				(20.89)	(46.58)	(19.09)
Race & Ethnicity						
Unknown				-94.57	-1169.1*	-399.6
				(180.2)	(470.9)	(260.8)
Black				-40.54**	-261.0***	-94.13***
				(12.62)	(27.34)	(11.64)
Hispanic				-137.2***	-360.2***	-177.4***
				(15.33)	(29.80)	(13.66)
Asian, Am Indian & Other				-61.78**	-239.7***	-91.64***
				(20.31)	(50.92)	(19.03)
Marital Status						
Married				7.473	98.90**	28.34*
				(15.12)	(35.93)	(14.00)
Divorced				66.49	252.3***	131.4***
				(41.50)	(69.49)	(35.61)

	Unadjusted			Adjusted		
	Male	Female	Pooled	Male	Female	Pooled
Education Level						
High School				-60.86***	-139.1***	-70.02***
				(12.50)	(35.32)	(11.76)
> High School				-175.1***	-203.9***	-174.5***
				(16.55)	(45.23)	(15.62)
Medical Waiver				49.58*	80.22	54.08**
				(20.32)	(57.83)	(19.45)
BCT Location						
Fort Bennning GA				52.85***	0	48.57***
				(13.22)	(.)	(13.21)
Fort Sill OK				111.7***	0	108.0***
				(14.30)	(.)	(14.20)
Fort Leonard Wood MO				-80.32***	-27.71	-58.08***
				(14.93)	(28.10)	(13.50)
Fort Knox KY				212.5***	0	214.2***
				(16.53)	(.)	(16.44)
Unknown & Other				35.74*	-25.03	25.07
				(15.90)	(35.65)	(14.64)
Female				0	0	661.2***
				(.)	(.)	(13.91)
Year Fixed Effects	No	No	No	Yes	Yes	Yes
N	278045	55302	333347	278045	55302	333347
R-Squared	0.0255	0.0388	0.0323	0.0297	0.0477	0.0427
F-Stat	5692.0	2709.5	9533.2	316.9	155.8	542.2

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Outcome 3: High-cost injuries

Methods

The aim of this analysis was to identify factors associated with very high direct medical costs among injured trainees. From the analysis for Outcome 2, it is evident that sustaining an injury is the largest predictor of total direct medical costs. This analysis therefore focuses on factors that further increase costs among injured trainees. A high-cost injury is defined here as an injury resulting in direct medical costs greater than $10,000 per trainee or an injury necessitating inpatient care.

A simple cross-tabulation was used to describe the characteristics of trainees with high-cost injuries. To determine the additional cost incurred when inpatient care is needed, an incremental cost approach was again taken, using the same basic regression model as for Outcome 2 above, with two changes. The outcome was again the total direct medical cost per trainee, but the analysis was limited to injured trainees and the regression model included an indicator for inpatient care instead of the injury indicator. All covariates remained the same.

Results

Trainees with High Costs

Table 4.8 shows the characteristics of trainees with very high medical costs (>$10,000) or needing inpatient care. Less than 1% of trainees sustained high-cost injuries. A total of 2641 trainees (0.79%) had total direct medical costs over $10,000, and 736 trainees (0.22%) required inpatient care.

Incurring costs over $10,000 was significantly associated with age, race/ethnicity, marital status, and education level. Of trainees over age 25, 1.00% incurred costs greater than $10,000, compared to 0.71% of trainees age 17-18. Only 0.63% of Hispanic trainees incurred costs greater than $10,000, compared to 0.68% of black trainees, 0.75% of Asian/American Indian/Other trainees, and 0.85% of white trainees. Among divorced trainees, 1.30% incurred costs greater than $10,000, compared to 0.93% of married trainees, and 0.76% of single trainees. Of trainees with more than a high school education, only 0.62% incurred costs greater than $10,000, compared to 0.76% of trainees completing high school, and 0.94% of trainees with less than a high school education.

Receiving inpatient care was significantly associated with BMI, age, and marital status. Of trainees with a BMI > 30, 0.35% received inpatient care, compared to 0.20% of trainees with a BMI < 25 and 0.22% of trainees with a BMI of 25-30. Of trainees over age 25, 0.32% received inpatient care, compared to 0.17% of trainees age 17-18. Among divorced trainees, 0.34% received inpatient care, compared to 0.28% of married trainees and 0.21% of single trainees.

Additional Medical Costs of Inpatient Care

Table 4.9 shows the additional medical cost of inpatient care, among injured trainees, after adjusting for BMI, age, race/ethnicity, marital status, education level, receiving a medical waiver

at accession, and BCT location. Receiving inpatient care increased mean costs by $7884.20 for men ($p<0.001$) and $5625.00 for women ($p<0.001$), above and beyond the mean cost of injury for each group.

Factors that Affect Costs, Controlling for Inpatient Care

Factors that significantly affect costs (at $p<0.01$) among injured trainees, after controlling for inpatient care status, are highlighted here.

Sociodemographic characteristics

Older age was still associated with increased costs for both men and women. Compared to trainees age 17-18, trainees over age 25 had mean medical costs $201.10 higher for men ($p<0.001$) and $208.60 higher for women ($p<0.001$).

For both men and women, black and Hispanic race/ethnicity were associated with decreased costs, compared to white trainees. The largest decreases were for Hispanic women (-$419.10, $p<0.001$), black women (-$324.80, $p<0.001$), Hispanic men (-$238.10, $p<0.001$), and black men (-$100.80, $p<0.001$).

Compared to trainees with less than a high school education, those with at least a high school education again experienced lower medical costs, and these differences were significant for both men and women. The largest decreases in costs were for trainees completing more than high school: -$232.40 for women ($p<0.001$) and -$207.20 for men ($p<0.001$), on average. Medical costs were also lower for trainees with only a high school education: -$188.30 ($p<0.001$) for women and -$74.23 ($p<0.01$) for men.

Compared to single women, divorced women had significantly higher medical costs (an additional $259.90, $p<0.01$), but married women did not. Marital status still did not significantly affect medical costs for men.

Anthropometric measures

Compared to men with a BMI of 18.5-25, men with a BMI > 30 had mean costs $131.30 higher ($p<0.001$). The cost increases associated with higher BMI for women did not disappear, but were not highly significant after controlling for inpatient care.

Training and accession characteristics

Medical costs again varied by training location for men, but not for women. Compared to male trainees at Fort Jackson, costs were still substantially higher for male trainees at Fort Knox ($386.10, $p<0.001$) and Fort Sill ($162.00, $p<0.001$). Medical costs were also still significantly lower for male trainees as Fort Leonard Wood (-$105.20, $p<0.01$). Having a medical waiver at accession was still not significantly associated with medical costs during BCT for men or women.

Table 4.8. Characteristics of trainees with high-cost injuries, men and women

	Cost > $10,000 n (%)		**Inpatient Care** n (%)		**Total** n
BMI					
<18.5	66	(0.78)	17	(0.20)	8446
18.5-25	1381	(0.77)	352	(0.20)	178866
25-30	934	(0.82)	256	(0.22)	114287
>30	260	(0.82)	111	(0.35)	31748
chi2	2.13		28.80		
p	0.545		2.47e-06		
Age					
17-18	718	(0.71)	174	(0.17)	101481
19-20	851	(0.81)	230	(0.22)	104578
21-24	632	(0.76)	193	(0.23)	83247
> 25	440	(1.00)	139	(0.32)	44041
chi2	35.01		29.65		
p	1.21e-07		1.64e-06		
Race & Ethnicity					
Unknown	0	(0.00)	0	(0.00)	7
White	1943	(0.85)	544	(0.24)	229676
Black	317	(0.68)	86	(0.19)	46481
Hispanic	239	(0.63)	76	(0.20)	38183
Asian, Am Indian & Other	142	(0.75)	30	(0.16)	19000
chi2	29.60		9.64		
p	5.90e-06		0.047		
Marital Status					
Single	2109	(0.76)	579	(0.21)	278482
Married	455	(0.93)	137	(0.28)	48945
Divorced	77	(1.30)	20	(0.34)	5920
chi2	35.54		13.54		
p	1.91e-08		0.001		
Education Level					
< High School	825	(0.94)	202	(0.23)	88172
High School	1555	(0.76)	444	(0.22)	203405
> High School	261	(0.62)	90	(0.22)	41770
chi2	39.96		0.388		
p	2.10e-09		0.824		
Total	2641	(0.79)	736	(0.22)	333347

Table 4.9. Additional medical costs of inpatient care, among injured trainees, 2000 US dollars

	Unadjusted			Adjusted		
	Male	Female	Pooled	Male	Female	Pooled
Constant	1556.8***	2238.2***	1716.9***	1172.6***	2008.6***	1157.1***
	(9.365)	(16.51)	(8.183)	(35.24)	(58.02)	(30.59)
Injured - Inpatient	7923.3***	5671.4***	7413.2***	7884.2***	5625.0***	7385.1***
	(801.0)	(960.0)	(658.7)	(799.7)	(954.4)	(657.7)
BMI						
< 18.5				58.07	-140.4*	-6.476
				(54.18)	(62.00)	(41.69)
25-30				52.52*	76.35*	56.55**
				(22.29)	(37.00)	(19.16)
> 30				131.3***	314.7	139.5***
				(32.60)	(205.0)	(32.26)
Age						
19-20				38.10	107.1*	55.75*
				(30.59)	(44.60)	(25.47)
21-24				44.43	67.47	52.28
				(32.21)	(49.77)	(27.09)
> 25				201.0***	208.6***	202.9***
				(40.52)	(63.16)	(34.46)
Race & Ethnicity						
Unknown				0	-1773.0***	-1829.0***
				(.)	(83.30)	(51.06)
Black				-100.8***	-324.8***	-174.2***
				(23.61)	(40.45)	(20.79)
Hispanic				-238.1***	-419.1***	-282.8***
				(31.51)	(43.04)	(25.99)
Asian, Am Indian & Other				-29.04	-201.7*	-67.66
				(48.19)	(79.72)	(41.15)
Marital Status						
Married				2.573	82.70	24.69
				(29.14)	(49.51)	(25.15)
Divorced				99.19	259.9**	163.7**
				(68.02)	(82.35)	(52.57)

	Unadjusted			Adjusted		
	Male	Female	Pooled	Male	Female	Pooled
Education Level						
High School				-74.23**	-188.3***	-96.45***
				(26.07)	(51.98)	(23.05)
> High School				-207.2***	-232.4***	-203.5***
				(33.25)	(64.47)	(29.35)
Medical Waiver				27.49	15.73	25.04
				(33.36)	(64.73)	(29.68)
BCT Location						
Fort Bennning GA				45.81	0	48.22
				(29.26)	(.)	(28.18)
Fort Sill OK				162.0***	0	161.8***
				(27.34)	(.)	(26.21)
Fort Leonard Wood MO				-105.2**	-61.74	-82.41**
				(33.72)	(40.47)	(25.89)
Fort Knox KY				386.1***	0	391.8***
				(33.28)	(.)	(32.40)
Unknown & Other				90.01**	67.62	87.77**
				(32.30)	(56.76)	(28.06)
Female				0	0	841.9***
				(.)	(.)	(22.98)
Year Fixed Effects	No	No	No	Yes	Yes	Yes
N	109760	33699	143459	109760	33699	143459
R-Squared	0.0277	0.0156	0.0245	0.0336	0.0269	0.0384
F-Stat	97.84	34.90	126.7	41.39	.	.

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Part 5:

Discussion and conclusions

This project used U.S. Army administrative data to study BCT-related injuries in a cohort of all individuals apparently undergoing BCT for the first time between January 1, 2002 and September 30, 2007. This study determined the incidence of BCT-related injuries, described those injuries, identified risk factors for those injuries, and estimated the direct medical costs incurred by the Army for those injuries.

Injuries

Among the entire cohort of basic trainees, 39.5% of men and 61.0% of women had at least one injury-related medical encounter during BCT. These rates are higher than those found in previous studies. As mentioned earlier, prior estimates of incidence rates of outpatient musculoskeletal injury among U.S. Army trainees were approximately 25% of men and 50% of women experiencing an injury during an eight-week period (Kaufman, Brodine et al., 2000).

There are several possible reasons for the higher rates found in this study. These findings most likely reflect a true increase in the incidence of BCT-related injury over time. Between the time of the earlier studies and this study, the length of BCT increased from eight weeks to ten weeks, thus increasing the risk period. This study also included injuries treated in the inpatient setting, which prior studies did not. However, the very low number of inpatient cases found here suggests that this could not possibly explain such a large difference in findings. Finally, this Army-wide study included all training locations, whereas prior studies were confined to one or two training sites. Because injury rates vary by training location, this could explain some of the difference in rates found. As this study is more comprehensive and more recent than prior research, the incidence rates presented here should be seen as more accurate for today's Army than prior estimates.

The same nine primary diagnoses were associated with the highest numbers of medical encounters for both men and women, though their rankings differed by gender. The most common reason for medical encounters for both men and women was "pain in joint, lower leg", accounting for approximately 15% of injury visits. Other common diagnoses were "pain in limb," "pain in joint, ankle & foot," "sprain of ankle, unspecified," "backache, unspecified," "low back pain," "sprains and strains of unspecified site of knee and leg," "joint pain, shoulder," and "pain in joint, pelvic region and thigh." This finding is consistent with prior research that has identified overuse injuries, strains, and sprains, especially in the lower extremities, as the most common types of training-related injuries (Kaufman, Brodine, et al., 2000).

For both men and women, older age, white race/ethnicity, lower educational attainment, being married or divorced vs. single, lower pay grade, and scoring lower on the Armed Forces Qualification Test (AFQT) were independently associated with increased injury risk. The findings on age are consistent with prior research showing strong evidence of an association between older age and increased risk of BCT-related injury (Bulzacchelli et al., 2014). Prior research on race/ethnicity and education level produced mixed or insufficient evidence of an association with injury risk (Bulzacchelli et al., 2014). This study provides much needed new

evidence for understanding the role of these factors. There is little prior research on marital status and risk of BCT-related injury. The finding that injury risk is higher for married and divorced trainees likely reflects uncontrolled confounding by age.

After controlling for all other factors, a one-unit difference in BMI was not associated with injury risk for men or women in this study. However, it is possible that a larger difference in BMI would be associated with injury risk. For women, very short height was associated with increased injury risk. This is likely because equipment is designed for an average-size man. Wherever possible, ergonomic principles should be used to design equipment for individuals of various dimensions to minimize injury risk.

Accession waivers, which were used as a proxy for pre-existing injury, were associated with increased risk of injury for men, but this association was not clear for women. Past research on prior injury as a risk factor for BCT-related injury has produced mixed findings for men and insufficient evidence for women (Bulzacchelli et al, 2014). The current study provides additional evidence of an association for men, but the question remains unsettled for women. Non-specific coding of reasons for accession waivers adds uncertainty to the interpretation of this finding.

Injury risk varied by training location. For men, training at Fort Benning was associated with higher injury risk than training at any of the other four locations. For women, training at Fort Leonard Wood was associated with higher injury risk than training at Fort Jackson. Differences in injury risk by training location have been reported in the past (Grier, Knapik, Canada, Canham-Chervak, Jones, 2010; Scott, Feltwell, Knapik, Barkley, Hauret, Bullock, et al., 2012; Swedler, Knapik, Williams, Grier, Jones, 2011) and might indicate differences in the application of training protocols, training conditions, or willingness of trainees to report injuries. This study was not able to determine reasons for differences in risk across training sites, as information about these potentially important factors is not available from centralized administrative databases. An in-depth study of the training environments and attitudes about injury in each of the five training sites is needed to fully understand the reasons for these findings, and would potentially lead to interventions to reduce future risks.

Costs

The cost analysis revealed that, overall, the Army spent an average of approximately $1200 on medical care per trainee over the study period. Injury status was the single largest predictor of direct medical costs. The mean medical cost per injured trainee was $1755.00, compared to $794.60 per non-injured trainee. Thus, for each injured trainee, the Army spent an additional $960.40, on average. After adjusting for other factors that affect costs, the mean additional cost of injury was determined to be $872.20 ($1093.70 for women, $825.90 for men). These additional costs of injury amounted to a total of $127,507,380 for the entire study period, or $21,929,700 per year.

There are no other studies of costs of BCT-related injuries available for comparison. However, a recent study of Division I collegiate athletes, Kaeding, Borchers, Oman, & Pedroza (2014) provides costs for a similar population. They studied the number of medical claims and expenses per claim for men's and women's sports teams for 14 college sports with corresponding male and female teams. They analyzed total charges from claims for all sports-related injury or illness experienced by team members from 2005-2010. For cross country teams, which are likely subject to injury risks similar to Army basic trainees, they found that the

men's team had 0.5 claims and $913 per athlete per year, compared to 1.1 claims and $1516 per athlete per year for the women's team, which equates to approximately $1800 per claim for men and $1500 per claim for women. These numbers are a little higher than the incremental cost of injury found in the present study, especially for the men.

In the current study, mean medical costs were higher for women than men, but predictors of cost were similar for men and women. Controlling for other factors that affect costs, increased costs were associated with older age, white race/ethnicity, lower educational attainment, and higher BMI, for both men and women. Medical costs were also higher for married and divorced women than for single women, but marital status did not significantly affect medical costs for men. Medical costs varied by training location for men, but not for women. Having a medical waiver at accession was not statistically significantly associated with medical costs during BCT for men or women.

Shi et al. (2015) used MEPS data to study medical expenditures associated with occupational injuries in the United States. They found an overall mean expenditure of $1953 (in 2011 US dollars) for 3034 non-fatally injured workers without persistent disabilities. This estimate rose to $2212 after controlling for other factors. These numbers are somewhat higher than the injury cost estimates produced by the current study, but likely reflect a different mix of injuries and cover a larger segment of the US population. Their analysis is useful for comparisons of risk factors for increased costs. Controlling for other factors, they found non-significant trends similar to those found in the present study for age ($2030 for age 18-24 vs. $2489 for age 25-44), and education ($2640 for > high school, $2892 for high school, and $3163 for < high school), but not for gender, race/ethnicity, or marital status.

For trainees who were not injured, mean medical costs were very similar across training locations. However, for injured trainees, mean costs varied by both type of injury and training location. Of the ten most common injury diagnoses, "physical therapy necessary" had the highest overall mean costs, at $2522.30 per trainee, followed by "pain in joint, pelvis & thigh," at $2512.60 per trainee. Over all injuries, Fort Benning had the lowest mean costs ($1566.50 per injured trainee) and Fort Jackson had the highest mean costs ($1916.40 per injured trainee). Variation in costs for the same type of injury sustained at different training locations ranged from $308 to $921. This variation in costs across training locations for the same type of injury could be due to differences in trainee characteristics, differences in injury severity within a given diagnosis, differences in treatment practices for injuries, differences in trainees' medical care seeking behavior for injuries, or regional differences in medical pricing for injury-related care. Information about injury severity, which was not available for this analysis, would be useful for future research and should be recorded along with the other medical encounter data.

Less than 1% of trainees sustained high-cost injuries. A total of 2641 trainees (0.79%) had total direct medical costs over $10,000, and 736 trainees (0.22%) required inpatient care. Incurring costs over $10,000 was associated with older age, white race/ethnicity, being married or divorced, and lower education level. Receiving inpatient care was associated with older age, being married or divorced, and higher BMI. Receiving inpatient care increased mean costs by $7884 for men and $5625 for women, above and beyond the mean cost of injury for each group.

The additional cost of inpatient care is consistent with findings from prior research. In the most comprehensive study of injury costs in the United States, Finkelstein, Corso, & Miller (2006) estimated that lifetime medical costs of a sprain/strain in the civilian population were $957 (in 2000 US dollars) per injury for non-hospitalized cases and $12,239 for hospitalized cases.

Methodological Considerations

Several challenges were encountered in the course of this study that created serious methodological limitations. The ability to carry out this project was hampered by insufficient data documentation, including incomplete or missing coding manuals and data dictionaries; incomplete training data (dates of starting and completing training; graduation status; training location); lack of pertinent trainee characteristics, such as fitness test scores and alcohol and tobacco use; and lack of indicators for separate injury episodes.

Algorithms were developed to identify potential first-time trainees and their training dates and injuries, but it was not possible to verify the validity or the completeness of the final data set. In fact, an error in defining the cohort of first-time trainees was discovered after the analysis was completed. Soldiers in pay grades E5-E7 should have been excluded from the cohort, but were not. As only 392 individuals included in the cohort (approximately 0.12% of the total) were in pay grades E5-E7, this error should not affect the results of the study.

The very large database provided superb statistical power to detect small magnitude differences between injured and non-injured trainees. Consequently, the analyses yielded some statistically significant associations that are not necessarily clinically significant or actionable. Trainers and policy makers must use their professional judgment in interpreting the findings presented here.

While statistical power was excellent, internal validity was jeopardized by the lack of data on important trainee characteristics. In this study, it was impossible to control for physical fitness and smoking, two characteristics known to be risk factors for BCT-related injuries (Bulzacchelli et al., 2014).

A final limitation is that the findings presented here do not reflect any changes made to recruitment or training protocols in the past ten years. They serve as baseline cost estimates. These analyses should be re-run with more recent data, and current costs should be compared to these baselines.

Conclusion

Approximately 40% of men and 61% of women sustained BCT-related injuries from 2002 to 2007. The most common types of injuries were sprains, strains, joint pain, and back pain. For each injured trainee, the Army incurs an estimated $872 in additional direct medical costs, which amounts to approximately $22 million annually.

These estimates include only direct costs of medical care. The additional costs of lost training time are not captured here. The economic burden of BCT-related injuries is therefore larger than these estimates suggest.

While the Army's current administrative data systems make this type of Army-wide analysis possible, these systems would be more useful for research purposes if they recorded BCT start and end dates for all trainees, trainee characteristics such as physical fitness and smoking, and information about injury severity. Data documentation must also be improved to facilitate research.

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Appendix

Table A1. ICD-9 Diagnosis codes taken to indicate injury-related care

Injuries Related Diagnose	ICD-9 Codes
Gen Osteoarthros-Hand	71504
General Osteoarthrosis	71509
Loc Prim Osteoart-Unspec	71510
Loc Prim Osteoart-Shlder	71511
Loc Prim Osteoart-Up/Arm	71512
Loc Prim Osteoarth-Hand	71514
Loc Prim Osteoart-Pelvis	71515
Loc Prim Osteoart-L/Leg	71516
Loc Prim Osteoarth-Ankle	71517
Loc Prim Osteoarthr Nec	71518
Loc 2nd Osteoarthro-Hand	71524
Loc 2nd Osteoarth-Pelvis	71525
Loc 2nd Osteoarthr-L/Leg	71526
Loc 2nd Osteoarthr-Ankle	71527
Loc 2nd Osteoarthros Nec	71528
Loc Osteoart Nos-Forearm	71533
Loc Osteoarth Nos-Hand	71534
Loc Osteoarth Nos-Pelvis	71535
Loc Osteoarth Nos-L/Leg	71536
Loc Osteoarth Nos-Ankle	71537
Osteoarthrosis-Mult Site	71580
Osteoarthrosis-Mult Site	71589
Osteoarthros Nos-Unspec	71590
Osteoarthros Nos-Shlder	71591
Osteoarthros Nos-Up/Arm	71592
Osteoarthros Nos-Forearm	71593
Osteoarthros Nos-Pelvis	71595
Osteoarthros Nos-L/Leg	71596
Osteoarthros Nos-Ankle	71597
Osteoarthro Nos-Oth Site	71598
Kaschin-Beck Dis-Unspec	71600
Traum Arthropathy-Unspec	71610

Traum Arthropathy-Shlder	71611
Traum Arthropathy-Up/Arm	71612
Traum Arthropath-Forearm	71613
Traum Arthropathy-Hand	71614
Traum Arthropathy-Pelvis	71615
Traum Arthropathy-L/Leg	71616
Traum Arthropathy-Ankle	71617
Traum Arthropathy-Mult	71619
Allerg Arthritis-Unspec	71620
Allerg Arthritis-Hand	71624
Allerg Arthritis-Pelvis	71625
Allerg Arthritis-Ankle	71627
Climact Arthritis-Shlder	71631
Climact Arthritis-Hand	71634
Climact Arthritis-Ankle	71637
Trans Arthropathy-Shlder	71641
Trans Arthropath-Forearm	71643
Trans Arthropathy-Hand	71644
Trans Arthropathy-Pelvis	71645
Trans Arthropathy-L/Leg	71646
Trans Arthropathy-Ankle	71647
Polyarthritis Nos-Unspec	71650
Polyarthrit Nos-Forearm	71653
Polyarthritis Nos-Hand	71654
Polyarthritis Nos-Pelvis	71655
Polyarthritis Nos-L/Leg	71656
Polyarthritis Nos-Mult	71659
Monoarthritis Nos-Unspec	71660
Monoarthritis Nos-L/Leg	71666
Monoarthritis Nos-Ankle	71667
Arthropathy Nec-Shlder	71681
Arthropathy Nec-Up/Arm	71682
Arthropathy Nec-Hand	71684
Arthropathy Nec-Pelvis	71685
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Sprain Sacrospinatus	8462
Sprain Sacroiliac Nec	8468
Sprain Sacroiliac Nos	8469
Sprain Of Neck	8470
Sprain Thoracic Region	8471
Sprain Lumbar Region	8472
Sprain Of Sacrum	8473
Sprain Of Coccyx	8474
Sprain Of Back Nos	8479
Sprain Of Nasal Septum	8480
Sprain Of Jaw	8481
Sprain Of Ribs	8483
Sprain Of Sternum Nos	84840
Sprain Sternoclavicular	84841
Sprain Chondrosternal	84842
Sprain Of Sternum Nec	84849
Sprain Of Pelvis	8485
Sprain Nec	8488
Sprain Nos	8489
Concussion W/O Coma	8500
Concus-Brief Coma <31 Mn	85011
Concus-Brf Coma 31-59 Mn	85012
Concussion-Moderate Coma	8502
Concussion W Coma Nos	8505
Concussion Nos	8509
Cerebral Cortx Contusion	85100

Cortex Contusion-No Coma	85101
Cortex Contus-Deep Coma	85105
Cortex Contus-Concus Nos	85109
Cerebral Cortex Lacerat	85120
Cortex Lacerat-Concuss	85129
Cerebel/Brain Stm Contus	85140
Cerebell Contus-Coma Nos	85146
Cerebell Contus-Concuss	85149
Cerebel Lacer W Open Wnd	85170
Brain Laceration Nec	85180
Brain Lacer Nec-Coma Nos	85186
Brain Lacer Nec-Concuss	85189
Traum Subarachnoid Hem	85200
Subarach Hem-Mod Coma	85203
Subarach Hem-Deep Coma	85205
Traumatic Subdural Hem	85220
Subdural Hem-Deep Coma	85225
Subdural Hemorr-Coma Nos	85226
Traumatic Extradural Hem	85240
Extradural Hem W/O Coma	85241
Extradural Hem-Mod Coma	85243
Extradural Hem-Coma Nos	85246
Extadural Hem-Concuss	85249
Extradural Hem-Coma Nos	85256
Traumatic Brain Hem Nec	85300
Brain Hem Nec-Brief Coma	85302
Brain Hem Nec-Coma Nos	85306
Brain Injury Nec	85400
Brain Injury Nec-No Coma	85401
Brain Inj Nec-Brief Coma	85402
Brain Inj Nec-Coma Nos	85406
Brain Inj Nec-Concussion	85409
Brain Injury W Opn Wnd	85410
Opn Brain Inj-Concussion	85419
Traum Pneumothorax-Close	8600

Traum Pneumothorax-Open	8601
Traum Pneumohemothor-Cl	8604
Heart Contusion-Closed	86101
Heart Injury Nos-Open	86110
Heart Contusion-Open	86111
Lung Injury Nos-Closed	86120
Lung Contusion-Closed	86121
Lung Laceration-Open	86132
Intrathoracic Inj Nec-Cl	86229
Intrathoracic Inj Nos-Cl	8628
Stomach Injury-Closed	8630
Small Intest Inj Nec-Opn	86339
Rectum Injury-Closed	86345
Rectum Injury-Open	86355
Pancreas Injury Nos-Clos	86384
Appendix Injury-Closed	86385
Gi Injury Nec-Closed	86389
Liver Injury Nos-Closed	86400
Liver Laceration, Mod	86403
Liver Lacerat Unspcf Cls	86405
Liver Injury Nos-Open	86410
Liver Lacerat, Minor-Opn	86412
Spleen Injury Nos-Closed	86500
Spleen Hematoma-Closed	86501
Spleen Capsular Tear	86502
Spleen Disruption-Clos	86504
Spleen Injury Nos-Open	86510
Spleen Hematoma-Open	86511
Spleen Injury Nec-Open	86519
Kidney Injury Nos-Closed	86600
Kidney Hematoma-Closed	86601
Kidney Disruption-Closed	86603
Bladder/Urethra Inj-Clos	8670
Bladder/Urethra Inj-Open	8671
Pelvic Organ Inj Nos-Opn	8679

Intra-Abdom Inj Nos-Clos	86800
Peritoneum Injury-Closed	86803
Intra-Abdom Inj Nos-Open	86810
Lac Eyelid Skn/Perioculr	8700
Full-Thicknes Lac Eyelid	8701
Lac Eyelid Inv Lacrm Pas	8702
Penetrat Wnd Orbit W Fb	8704
Opn Wnd Ocular Adnex Nec	8708
Opn Wnd Ocular Adnex Nos	8709
Ocular Lac W/O Prolapse	8710
Ocular Lacera W Prolapse	8711
Rupture Eye W Tissu Loss	8712
Avulsion Of Eye	8713
Laceration Of Eye Nos	8714
Penetrat Fb Nec Eye	8716
Ocular Penetration Nos	8717
Opn Wound Of Eyeball Nos	8719
Opn Wound Extern Ear Nos	87200
Open Wound Of Auricle	87201
Opn Wound Auditory Canal	87202
Opn Wnd Ex Ear Nos-Compl	87210
Open Wnd Aud Canal-Compl	87212
Open Wound Of Ear Drum	87261
Open Wound Of Ear Nec	87269
Open Wnd Ear Drum-Compl	87271
Open Wound Ear Nec-Compl	87279
Open Wound Of Ear Nos	8728
Open Wound Ear Nos-Compl	8729
Open Wound Of Scalp	8730
Open Wound Scalp-Compl	8731
Open Wound Of Nose Nos	87320
Open Wound Nasal Septum	87321
Open Wound Nasal Cavity	87322
Mult Open Wound Nose	87329
Open Wnd Nose Nos-Compl	87330

Opn Wnd Nas Septum-Compl	87331
Open Wnd Nasal Cav-Compl	87332
Open Wound Of Face Nos	87340
Open Wound Of Cheek	87341
Open Wound Of Forehead	87342
Open Wound Of Lip	87343
Open Wound Of Jaw	87344
Open Wound Of Face Nec	87349
Open Wnd Face Nos-Compl	87350
Open Wnd Forehead-Compl	87352
Open Wound Lip-Complicat	87353
Open Wound Jaw-Complicat	87354
Open Wnd Face Nec-Compl	87359
Open Wound Of Mouth Nos	87360
Open Wound Buccal Mucosa	87361
Open Wound Of Gum	87362
Broken Tooth-Uncomplic	87363
Opn Wnd Tongue/Mouth Flr	87364
Open Wound Of Palate	87365
Open Wound Mouth Nec	87369
Broken Tooth-Complicated	87373
Open Wound Tongue-Compl	87374
Open Wound Of Head Nec	8738
Open Wnd Head Nec-Compl	8739
Open Wound Pharynx-Compl	8745
Open Wound Of Neck Nec	8748
Open Wound Of Chest	8750
Open Wound Chest-Compl	8751
Open Wound Of Back	8760
Open Wound Back-Compl	8761
Open Wound Of Buttock	8770
Open Wound Buttock-Compl	8771
Open Wound Of Penis	8780
Opn Wound Scrotum/Testes	8782
Opn Wnd Scrot/Test-Compl	8783

Open Wound Of Vulva	8784
Open Wound Of Vagina	8786
Open Wound Of Breast	8790
Opn Wnd Anterior Abdomen	8792
Opn Wnd Ant Abdomen-Comp	8793
Opn Wnd Lateral Abdomen	8794
Open Wound Of Trunk Nec	8796
Open Wound Site Nos	8798
Opn Wound Site Nos-Compl	8799
Open Wound Of Shoulder	88000
Open Wound Of Scapula	88001
Open Wound Of Axilla	88002
Open Wound Of Upper Arm	88003
Mult Open Wound Shoulder	88009
Open Wnd Shoulder-Compl	88010
Open Wound Axilla-Compl	88012
Open Wnd Axilla W Tendon	88022
Open Wound Of Forearm	88100
Open Wound Of Elbow	88101
Open Wound Of Wrist	88102
Open Wound Forearm-Compl	88110
Open Wound Elbow-Complic	88111
Open Wound Wrist-Complic	88112
Open Wnd Forearm W Tendn	88120
Opn Wound Wrist W Tendon	88122
Open Wound Of Hand	8820
Opn Wound Hand-Complicat	8821
Open Wound Hand W Tendon	8822
Open Wound Of Finger	8830
Open Wound Finger-Compl	8831
Open Wnd Finger W Tendon	8832
Open Wound Arm Mult/Nos	8840
Open Wound Arm Nos-Compl	8841
Opn Wnd Arm Nos W Tendon	8842
Amputation Thumb	8850

Amputation Finger	8860
Open Wound Of Hip/Thigh	8900
Open Wnd Hip/Thigh-Compl	8901
Opn Wnd Hip/Thigh W Tend	8902
Open Wnd Knee/Leg/Ankle	8910
Open Wnd Knee/Leg-Compl	8911
Opn Wnd Knee/Leg W Tendn	8912
Open Wound Of Foot	8920
Open Wound Foot-Compl	8921
Open Wound Foot W Tendon	8922
Open Wound Of Toe	8930
Open Wound Toe-Compl	8931
Open Wound Toe W Tendon	8932
Open Wound Of Leg Nec	8940
Open Wound Leg Nec-Compl	8941
Amputation Toe	8950
Amputation Toe-Complicat	8951
Amputation Foot, Unilat	8960
Inj Mlt Head/Neck Vessel	90082
Inj Head/Neck Vessel Nec	90089
Inj Head/Neck Vessel Nos	9009
Inj Intercostal Art/Vein	90181
Inj Infer Vena Cava Nos	90210
Injury Renal Vessel Nos	90240
Injury Renal Artery	90241
Injury Radial Vessels	9032
Injury Palmar Artery	9034
Injury Finger Vessels	9035
Injury Arm Vessel Nos	9039
Injury Tibial Vessel Nos	90450
Inj Anterior Tibial Vein	90452
Injury Leg Vessel Nos	9048
Late Effec Skull/Face Fx	9050
Late Eff Spine/Trunk Fx	9051
Late Effect Arm Fx	9052

Late Eff Femoral Neck Fx	9053
Late Effect Leg Fx	9054
Late Effect Fracture Nec	9055
Late Effect Dislocation	9056
Late Effec Sprain/Strain	9057
Late Effec Tendon Injury	9058
Lt Eff Opn Wnd Head/Trnk	9060
Late Eff Open Wnd Extrem	9061
Late Eff Superficial Inj	9062
Late Effect Of Contusion	9063
Late Effect Of Crushing	9064
Late Eff Head/Neck Burn	9065
Late Eff Wrist/Hand Burn	9066
Late Eff Burn Extrem Nec	9067
Late Effect Of Burns Nec	9068
Late Effect Of Burn Nos	9069
Lt Eff Intracranial Inj	9070
Lt Eff Nerv Inj Shld/Arm	9074
Late Eff Complic Trauma	9086
Late Effect Injury Nos	9089
Abrasion Head	9100
Abrasion Head-Infected	9101
Blister Head	9102
Blister Head-Infected	9103
Insect Bite Head	9104
Insect Bite Head-Infect	9105
Foreign Body Head	9106
Superfic Inj Head Nec	9108
Superf Inj Head Nec-Inf	9109
Abrasion Trunk	9110
Abrasion Trunk-Infected	9111
Blister Trunk	9112
Blister Trunk-Infected	9113
Insect Bite Trunk	9114
Insect Bite Trunk-Infec	9115

Foreign Body Trunk	9116
Superfic Inj Trunk Nec	9118
Superf Inj Trnk Nec-Inf	9119
Abrasion Shoulder/Arm	9120
Abrasion Shldr/Arm-Infec	9121
Blister Shoulder & Arm	9122
Blister Shoulder/Arm-Inf	9123
Insect Bite Shoulder/Arm	9124
Insect Bite Shld/Arm-Inf	9125
Foreign Body Shouldr/Arm	9126
Fb Shoulder/Arm-Infect	9127
Superf Inj Shldr/Arm Nec	9128
Superf Inj Shldr Nec-Inf	9129
Abrasion Forearm	9130
Abrasion Forearm-Infect	9131
Blister Forearm	9132
Blister Forearm-Infected	9133
Insect Bite Forearm	9134
Insect Bite Forearm-Inf	9135
Foreign Body Forearm	9136
Superf Inj Forearm Nec	9138
Suprf Inj Forarm Nec-Inf	9139
Abrasion Hand	9140
Abrasion Hand-Infected	9141
Blister Hand	9142
Blister Hand-Infected	9143
Insect Bite Hand	9144
Insect Bite Hand-Infect	9145
Foreign Body Hand	9146
Foreign Body Hand-Infect	9147
Superficial Inj Hand Nec	9148
Superf Inj Hand Nec-Inf	9149
Abrasion Finger	9150
Abrasion Finger-Infected	9151
Blister Finger	9152

Blister Finger-Infected	9153
Insect Bite Finger	9154
Insect Bite Finger-Infec	9155
Foreign Body Finger	9156
Foreign Body Finger-Inf	9157
Superfic Inj Finger-Nec	9158
Suprf Inj Finger Nec-Inf	9159
Abrasion Hip & Leg	9160
Abrasion Hip/Leg-Infect	9161
Blister Hip & Leg	9162
Blister Hip & Leg-Infect	9163
Insect Bite Hip & Leg	9164
Insect Bite Hip/Leg-Inf	9165
Foreign Body Hip/Leg	9166
Superfic Inj Hip/Leg Nec	9168
Superf Inj Leg Nec-Infec	9169
Abrasion Foot & Toe	9170
Abrasion Foot/Toe-Infec	9171
Blister Foot & Toe	9172
Blister Foot & Toe-Infec	9173
Insect Bite Foot/Toe	9174
Insect Bite Foot/Toe-Inf	9175
Foreign Body Foot & Toe	9176
Foreign Bdy Foot/Toe-Inf	9177
Superf Inj Foot/Toe Nec	9178
Superf Inj Foot Nec-Inf	9179
Superfic Inj Periocular	9180
Superficial Inj Cornea	9181
Superfic Inj Conjunctiva	9182
Superficial Inj Eye Nec	9189
Abrasion Nec	9190
Abrasion Nec-Infected	9191
Blister Nec	9192
Blister Nec-Infected	9193
Insect Bite Nec	9194

Insect Bite Nec-Infected	9195
Superfic Foreign Bdy Nec	9196
Superficial Fb Nec-Infec	9197
Superficial Injury Nec	9198
Superfic Inj Nec-Infect	9199
Contusion Face/Scalp/Nck	920
Black Eye Nos	9210
Contusion Periocular	9211
Contusion Orbital Tissue	9212
Contusion Of Eyeball	9213
Contusion Of Eye Nos	9219
Contusion Of Breast	9220
Contusion Of Chest Wall	9221
Contusion Abdominal Wall	9222
Back Contusion	92231
Buttock Contusion	92232
Interscplr Reg Contusion	92233
Contusion Genital Organs	9224
Multiple Contusion Trunk	9228
Contusion Trunk Nos	9229
Contusion Shoulder Reg	92300
Contusion Scapul Region	92301
Contusion Axillary Reg	92302
Contusion Of Upper Arm	92303
Contusion Shoulder & Arm	92309
Contusion Of Forearm	92310
Contusion Of Elbow	92311
Contusion Of Hand(S)	92320
Contusion Of Wrist	92321
Contusion Of Finger	9233
Multiple Contusion Arm	9238
Contusion Upper Limb Nos	9239
Contusion Of Thigh	92400
Contusion Of Hip	92401
Contusion Of Lower Leg	92410

Contusion Of Knee	92411
Contusion Of Foot	92420
Contusion Of Ankle	92421
Contusion Of Toe	9243
Multiple Contusion Leg	9244
Contusion Leg Nos	9245
Multiple Contusions Nec	9248
Contusion Nos	9249
Crush Inj Face Scalp	9251
Crush Inj Neck	9252
Crush Inj Ext Genitalia	9260
Crushing Injury Back	92611
Crushing Injury Buttock	92612
Crushing Inj Trunk Nos	9269
Crush Inj Scapul Region	92701
Crushing Inj Upper Arm	92703
Crushing Injury Forearm	92710
Crushing Injury Elbow	92711
Crushing Injury Of Hand	92720
Crushing Injury Of Wrist	92721
Crushing Injury Finger	9273
Crushing Injury Arm Nos	9279
Crushing Injury Hip	92801
Crushing Inj Lower Leg	92810
Crushing Injury Knee	92811
Crushing Injury Foot	92820
Crushing Injury Ankle	92821
Crushing Injury Toe	9283
Mult Crushing Injury Leg	9288
Crushing Injury Nos	9299
Chemical Burn Periocular	9400
Burn Periocular Area Nec	9401
Alkal Burn Cornea/Conjun	9402
Acid Burn Cornea/Conjunc	9403
Burn Cornea/Conjunct Nec	9404

Burn Eye & Adnexa Nos	9409
Burn Nos Head-Unspec	94100
Burn Nos Lip	94103
Burn Nos Chin	94104
Burn Nos Scalp	94106
Burn Nos Face Nec	94107
Burn Nos Neck	94108
Burn Nos Head-Mult	94109
1st Deg Burn Head Nos	94110
1st Deg Burn Ear	94111
1st Deg Burn Scalp	94116
1st Deg Burn Face Nec	94117
1st Deg Burn Neck	94118
1st Deg Burn Head-Mult	94119
2nd Deg Burn Head Nos	94120
2nd Deg Burn Lip	94123
2nd Deg Burn Chin	94124
2nd Deg Burn Face Nec	94127
2nd Deg Burn Neck	94128
2nd Deg Burn Head-Mult	94129
Burn Nos Chest Wall	94202
Burn Nos Abdominal Wall	94203
Burn Nos Back	94204
Burn Nos Genitalia	94205
Burn Nos Trunk Nec	94209
1st Deg Burn Chest Wall	94212
1st Deg Burn Back	94214
2nd Deg Burn Trunk Nos	94220
2nd Deg Burn Breast	94221
2nd Deg Burn Chest Wall	94222
2nd Deg Burn Back	94224
Burn Nos Arm-Unspec	94300
Burn Nos Forearm	94301
Burn Nos Elbow	94302
Burn Nos Upper Arm	94303

Burn Nos Axilla	94304
Burn Nos Scapula	94306
Burn Nos Arm-Multiple	94309
1st Deg Burn Arm Nos	94310
1st Deg Burn Forearm	94311
1st Deg Burn Upper Arm	94313
1st Deg Burn Shoulder	94315
2nd Deg Burn Arm Nos	94320
2nd Deg Burn Forearm	94321
2nd Deg Burn Shoulder	94325
Burn Nos Hand-Unspec	94400
Burn Nos Finger	94401
Burn Nos Thumb	94402
Burn Nos Mult Fingers	94403
Burn Nos Finger W Thumb	94404
Burn Nos Palm	94405
Burn Nos Back Of Hand	94406
Burn Nos Wrist	94407
Burn Nos Hand-Multiple	94408
1st Deg Burn Hand Nos	94410
1st Deg Burn Finger	94411
1st Deg Burn Mult Finger	94413
1st Deg Burn Palm	94415
1st Deg Burn Wrist	94417
2nd Deg Burn Hand Nos	94420
2nd Deg Burn Finger	94421
2nd Deg Burn Mult Finger	94423
2 Deg Burn Fingr W Thumb	94424
2nd Deg Burn Palm	94425
2 Deg Burn Back Of Hand	94426
2nd Deg Burn Wrist	94427
2nd Deg Burn Hand-Mult	94428
3rd Deg Burn Hand Nos	94430
Burn Nos Leg-Unspec	94500
Burn Nos Toe	94501

Burn Nos Foot	94502
Burn Nos Ankle	94503
Burn Nos Lower Leg	94504
Burn Nos Knee	94505
Burn Nos Thigh	94506
Burn Nos Leg-Multiple	94509
1st Deg Burn Leg Nos	94510
1st Deg Burn Knee	94515
2nd Deg Burn Leg Nos	94520
2nd Deg Burn Toe	94521
2nd Deg Burn Foot	94522
2nd Deg Burn Ankle	94523
2nd Deg Burn Lower Leg	94524
Burn Nos Multiple Site	9460
1st Deg Burn Mult Site	9461
2nd Deg Burn Mult Site	9462
3rd Deg Burn Mult Site	9463
Burn Of Mouth & Pharynx	9470
Bdy Brn < 10%/3d Deg Nos	94800
10-19% Bdy Brn/3 Deg Nos	94810
40-49% Bdy Brn/3 Deg Nos	94840
Burn Nos	9490
1st Degree Burn Nos	9491
2nd Degree Burn Nos	9492
Inj Optic Nerv/Path Nos	9509
Injury Trochlear Nerve	9511
Injury To Facial Nerve	9514
Injury Accessory Nerve	9516
C1-C4 Spin Cord Inj Nos	95200
C1-C4 Spin Cord Inj Nec	95204
T1-T6 Spin Cord Inj Nos	95210
Lumbar Spinal Cord Injur	9522
Cauda Equina Injury	9524
Spin Cord Inj-Mult Site	9528
Spinal Cord Injury Nos	9529

Cervical Root Injury	9530
Dorsal Root Injury	9531
Lumbar Root Injury	9532
Sacral Root Injury	9533
Brachial Plexus Injury	9534
Inj Nerve Root/Plex Nos	9539
Injury Axillary Nerve	9550
Injury Median Nerve	9551
Injury Ulnar Nerve	9552
Injury Radial Nerve	9553
Inj Musculocutan Nerve	9554
Inj Cutan Senso Nerv/Arm	9555
Injury Digital Nerve	9556
Inj Nerve Shldr/Arm Nec	9557
Inj Nerve Shldr/Arm Nos	9559
Injury Sciatic Nerve	9560
Injury Femoral Nerve	9561
Injury Peroneal Nerve	9563
Inj Cutan Senso Nerv/Leg	9564
Inj Nerve Pelv/Leg Nec	9565
Inj Mult Nerve Pelv/Leg	9568
Inj Nerve Pelv/Leg Nos	9569
Injury To Nerve Nec	9571
Injury To Mult Nerves	9578
Injury To Nerve Nos	9579
Posttraum Wnd Infec Nec	9583
Traumatic Shock	9584
Traumatic Anuria	9585
Traum Subcutan Emphysema	9587
Early Complic Trauma Nec	9588
Compartment Syndrome Nos	95890
Trauma Comp Synd Low Ext	95892
Head Injury Nos	95901
Face & Neck Injury	95909
Injury Of Chest Wall Nec	95911

Injury Of Abdomen Nec	95912
Fx Corpus Cavrnosm Penis	95913
Inj External Genital Nec	95914
Trunk Injury-Sites Nec	95919
Shldr/Upper Arm Inj Nos	9592
Elb/Forearm/Wrst Inj Nos	9593
Hand Injury Nos	9594
Finger Injury Nos	9595
Hip & Thigh Injury Nos	9596
Lower Leg Injury Nos	9597
Injury Mlt Site/Site Nec	9598
Injury-Site Nos	9599
Fit Orthopedic Devices	V537
Aftercare Joint Replace	V5481
Orthopedic Aftercare Nec	V5489
Orthopedic Aftercare Nos	V549
Physical Therapy Nec	V571
Encntr Occupatnal Thrpy	V5721
Encntr Vocational Thrpy	V5722
Attn Rem Nonsurg Dressng	V5830
Attn Rem Surg Dressing	V5831
Attn Removal Of Sutures	V5832
Postop Oth Specfd Aftrcr	V5849
Observ-Work Accident	V713
Observ-Accident Nec	V714

Table A2. ICD-9 Procedure codes taken to indicate injury-related care

Injuries Related Procedure	ICD-9 Codes
Anesth Inject-Spin Canal	0391
Bone Scan	9214
C.A.T. Scan Of Head	8703
C.A.T. Scan Of Thorax	8741
Chest X-Ray Nec	8749
Debrid Opn Fx-Radius/Uln	7962
Drain Face & Mouth Floor	270
Dressing Of Wound Nec	9357
Dx Ultrasound Nec	8879
Dx Ultrasound-Urinary	8875
Dx Ultrasound-Vascular	8877
Facial Bone Sequestrect	7601
Inject Antibiotic	9921
Inject Steroid	9923
Insert Endotracheal Tube	9604
Insert Intercostal Cath	3404
Internal Fixation-Femur	7855
Iridoplasty Nec	1239
Loc Exc Bone Les Patella	7766
Op Red-Int Fix Rad/Ulna	7932
Op Red-Int Fix Tib/Fibul	7936
Oth Arthrotomy-Knee	8016
Other C.A.T. Scan	8838
Other Repair Of Knee	8147
Other Skin & Subq I & D	8604
Oxygen Enrichment Nec	9396
Packed Cell Transfusion	9904
Physical Therapy Nec	9339
Platelet Transfusion	9905
Remove Int Fix Face Bone	7697
Routine Chest X-Ray	8744
Scrotum & Tunica I & D	610
Skel Xray-Ankle & Foot	8828
Skel Xray-Pelvis/Hip Nec	8826
Suture Scleral Lacer	1281

Table A3. ICD-9 Diagnose and Procedure codes (combined) taken to indicate injury-related care

Procedure1	Procedure2	Procedure3	Procedure4	Dx1	Dx2	ID	Include Or Exclude?
C.A.T. Scan Of Head	Cardiac Stress Test Nec	Nebulizer Therapy	Dx Ultrasound-Heart	Syncope And Collapse	Asthma Nos	35333	Include
Nebulizer Therapy				Pneumonia, Organism Nos	Hyposmolality	65740	Exclude
Nebulizer Therapy				Pneumonia, Organism Nos	Hypopotassemia	66872	Exclude
Inject Antibiotic	Inject/Infuse Nec	Nebulizer Therapy		Pneumonia, Organism Nos	Dehydration	68895	Exclude
Nebulizer Therapy				Pneumonia, Organism Nos	Hypopotassemia	83335	Exclude
Nebulizer Therapy				Pneumonia, Organism Nos	Hyposmolality	91762	Exclude
Nebulizer Therapy				Pneumonia, Organism Nos	Hyposmolality	112631	Exclude
Nebulizer Therapy				493924	Hypopotassemia	121666	Exclude
Nebulizer Therapy	Bone Scan			Pneumo Oth Grm-Neg Bact	Early Complic Trauma Nec	153100	Include
Other Skin & Subq I & D	Nebulizer Therapy	Oxygen Enrichment Nec		Pneumonia, Organism Nos	Blister Foot & Toe	193956	Exclude
Dx Ultrasound-Heart	Cardiac Stress Test Nec	Nebulizer Therapy		Syncope And Collapse	Asthma Nos	297404	Include
Nebulizer Therapy				Pneumonia, Organism Nos	Hyposmolality	328773	Exclude
Dx Ultrasound-Heart	Nebulizer Therapy			Syncope And Collapse	Exercse Ind Bronchospasm	330823	Include
Nebulizer Therapy				Pneumonia, Organism Nos	Hypopotassemia	341543	Exclude
Nebulizer Therapy				Pneumonia, Organism Nos	Hyposmolality	342184	Exclude
Inject Antibiotic	Inject/Infuse Nec	Nebulizer Therapy		Pneumonia, Organism Nos	Hypopotassemia	354159	Exclude
Nebulizer Therapy				Pneumonia, Organism Nos	Hypopotassemia	358801	Exclude
Nebulizer Therapy				493921	Hypopotassemia	399505	Exclude
Nebulizer Therapy				Pneumonia, Organism Nos	Hypopotassemia	410677	Exclude